United States Patent [19]

Bloxham et al.

[11] **4,075,299**

[45] **Feb. 21, 1978**

[54] **METHOD OF MAKING RETRACTILE CORDS**

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[73] Assignee: **Western Electric Company, Inc.,** New York, N.Y.

[21] Appl. No.: **706,729**

[22] Filed: **July 19, 1976**

Related U.S. Application Data

[62] Division of Ser. No. 641,003, Dec. 15, 1975, Pat. No. 3,988,092.

[51] **Int. Cl.**² **B29C 27/20**

[52] **U.S. Cl.** **264/25;** 264/159; 264/281

[58] **Field of Search** 264/25, 145, 159, 281, 264/286

[56] **References Cited**

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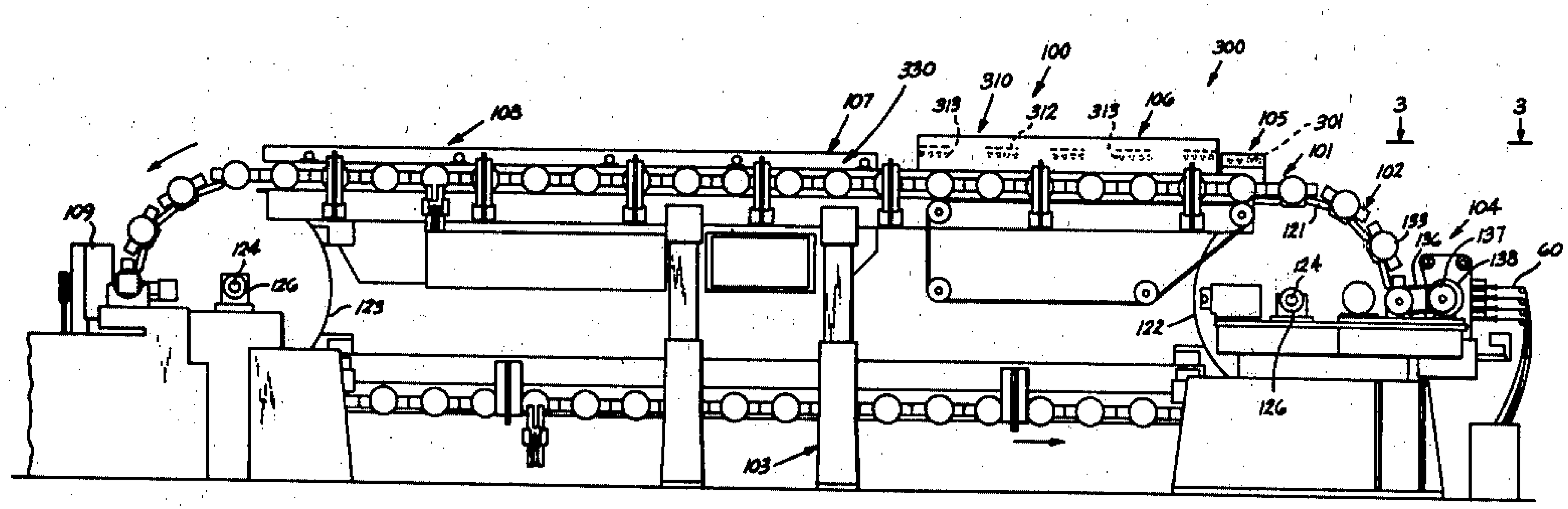
Primary Examiner—Richard R. Kucia
Attorney, Agent, or Firm—E. W. Somers; A. C. Schwarz, Jr.

[57] **ABSTRACT**

A plurality of groups of mandrels are arranged for movement successively through a plurality of workstations with each group being worked on at a station while other groups are being worked on simultaneously at other stations to produce continuously automatically groups of retractile cords. Cordage is fed from a supply into clamping engagement with each of the mandrels in the group in a cord-loading position and then wound helically in a plurality of spaced-apart convolutions on each of the mandrels of that group after which the wound cords are severed from the cordage supplies. The wound cords are advanced incrementally through a heating zone, wherein the cords are exposed to radiant heating supplemented by preheating of the mandrels, while cordage is being wound on the next successive groups of mandrels. The wound cords in each group are advanced through a cooling zone and then to an unloading station where they are removed from the mandrels while the pitch of the helices of the convolutions is reversed and the tendency of the convolutions to enlarge is minimized.

7 Claims, 21 Drawing Figures



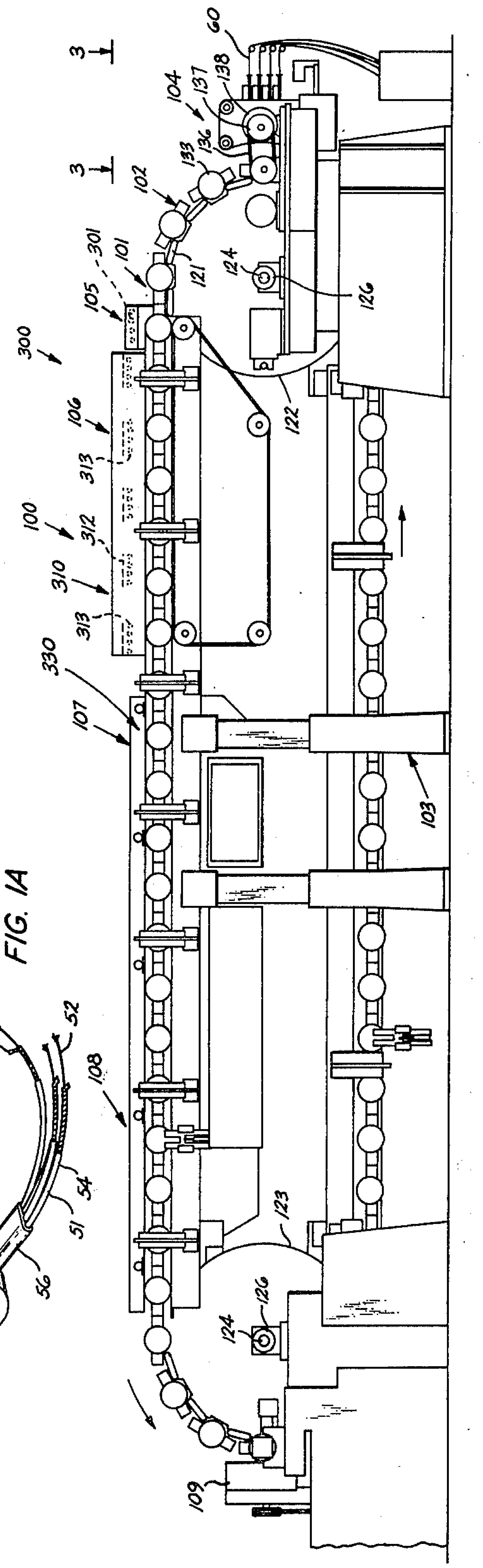

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FIG. 1

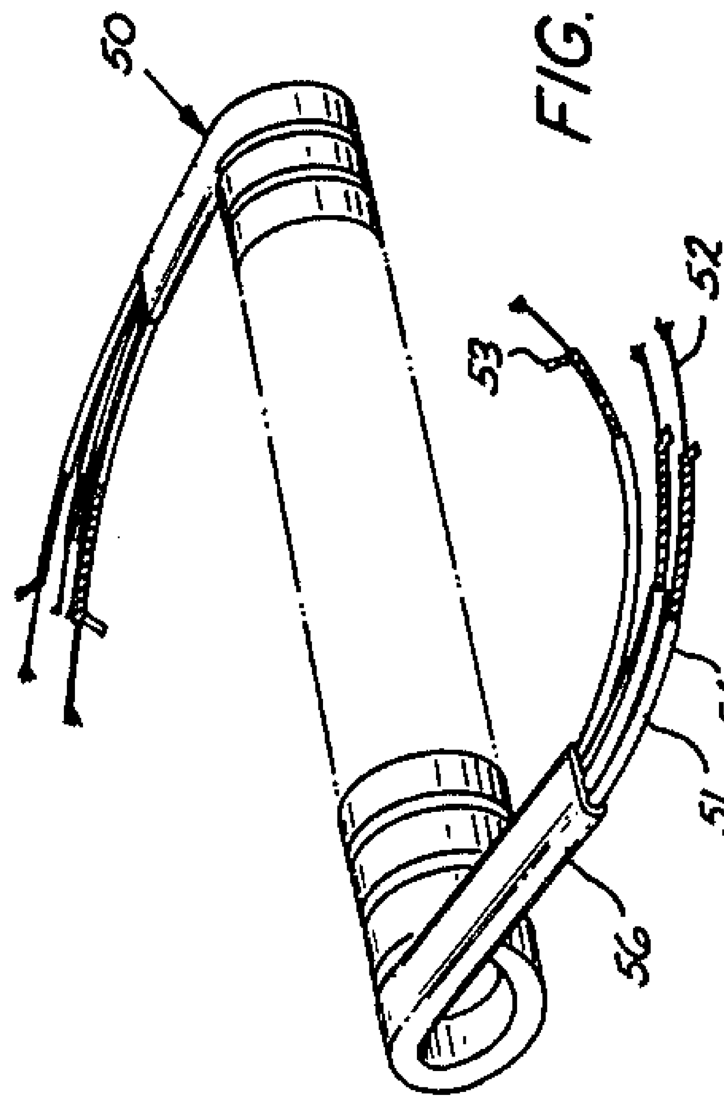
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FIG. 1A

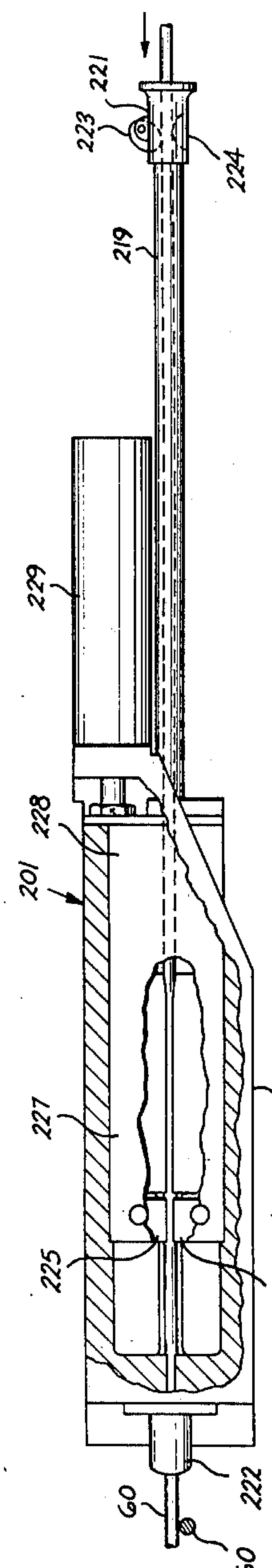
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FIG. 6

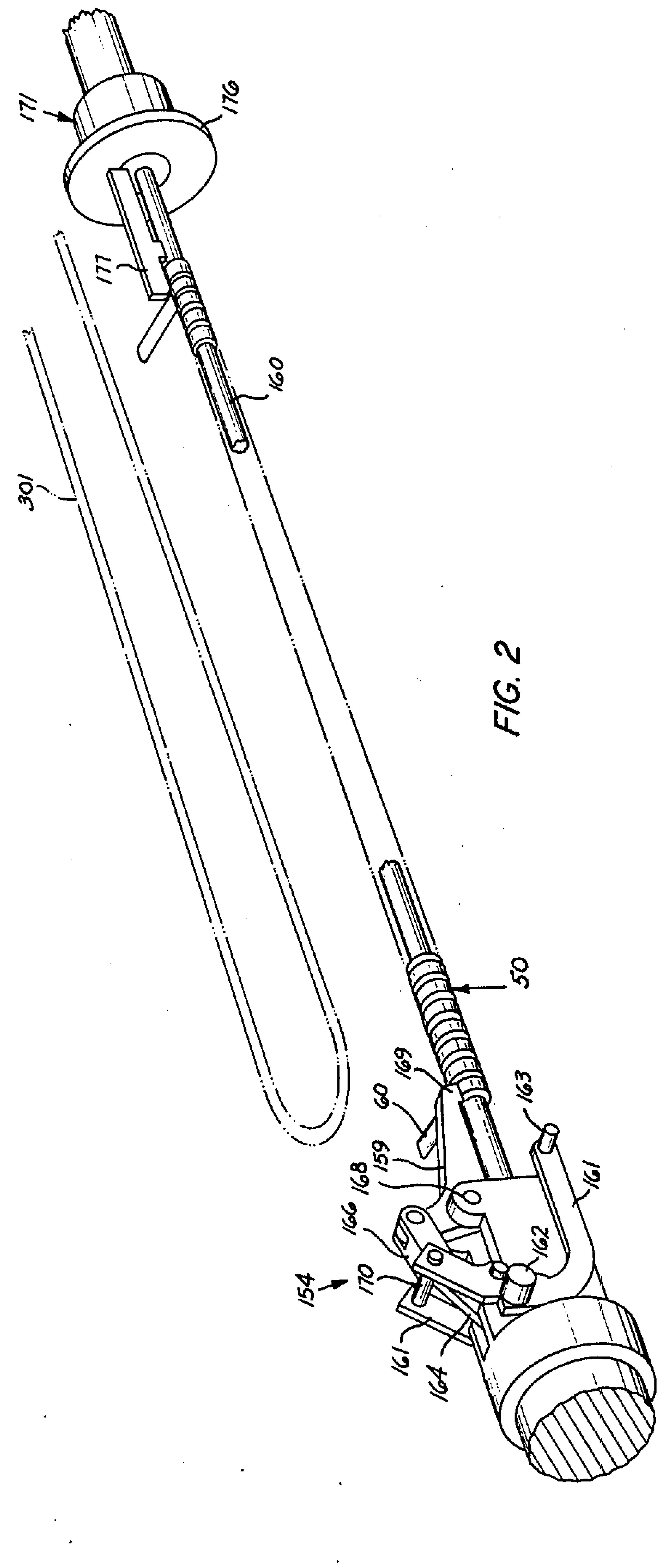
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FIG. 2

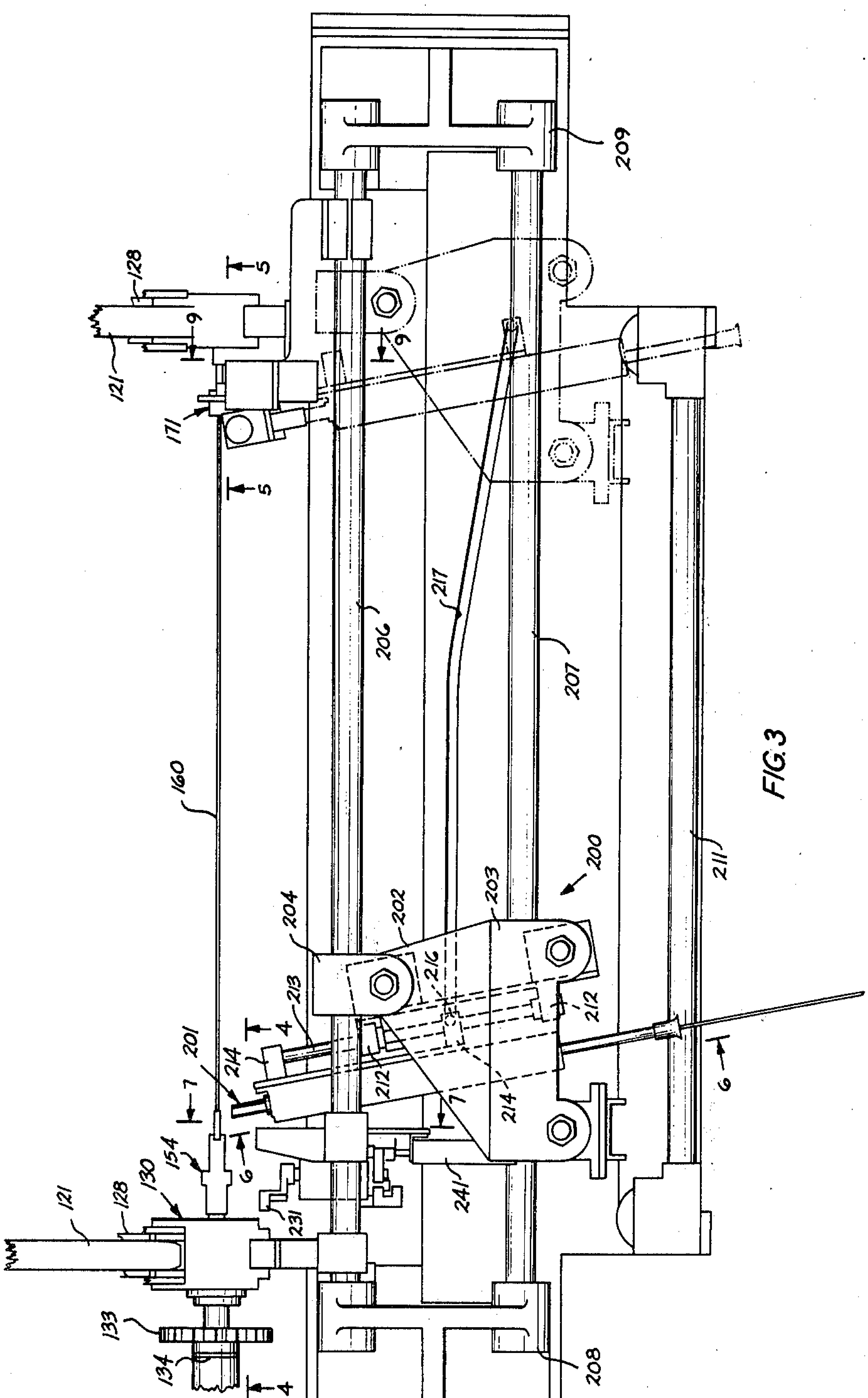
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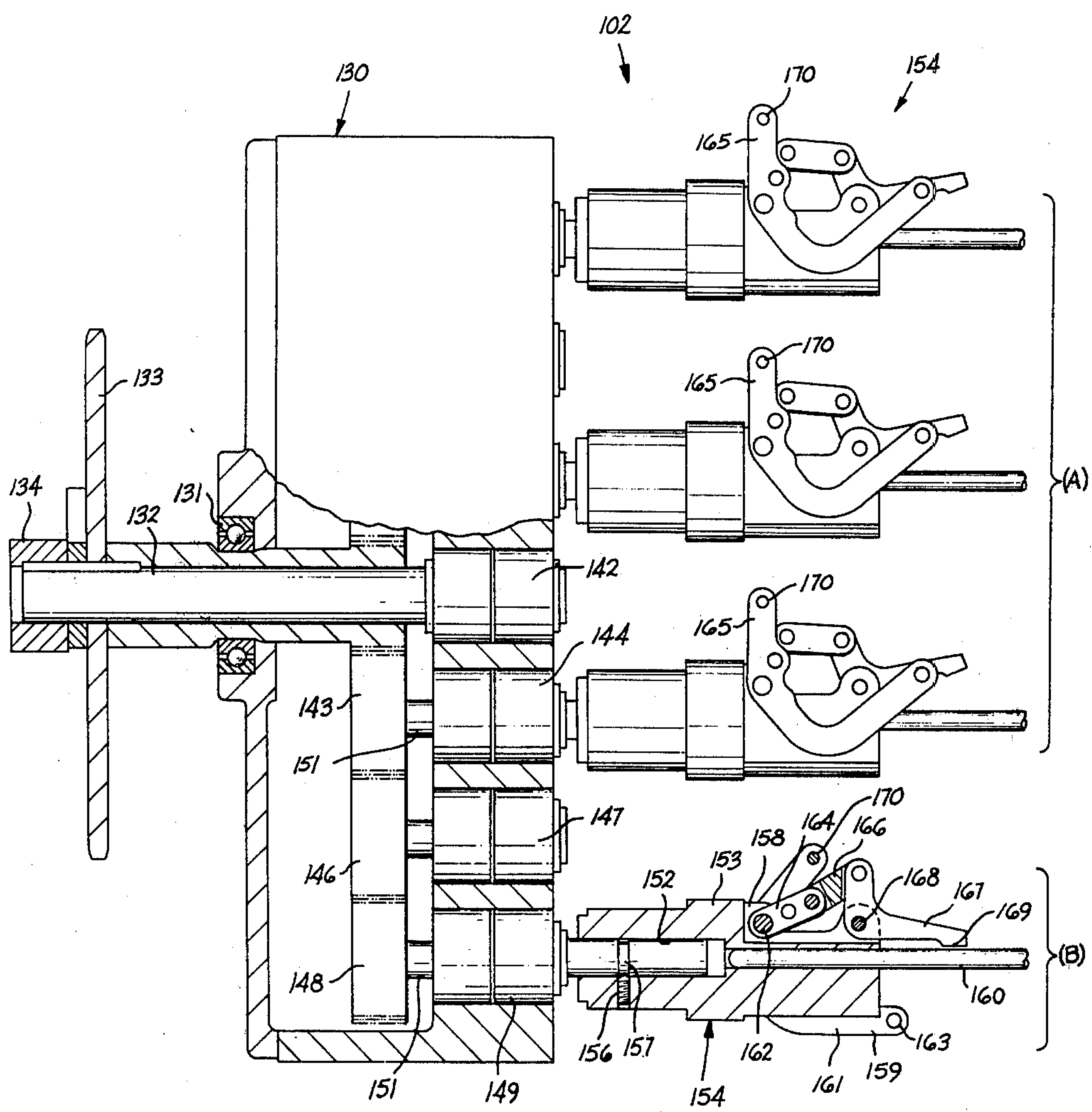
FIG. 3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(A)
(B)

FIG. 4

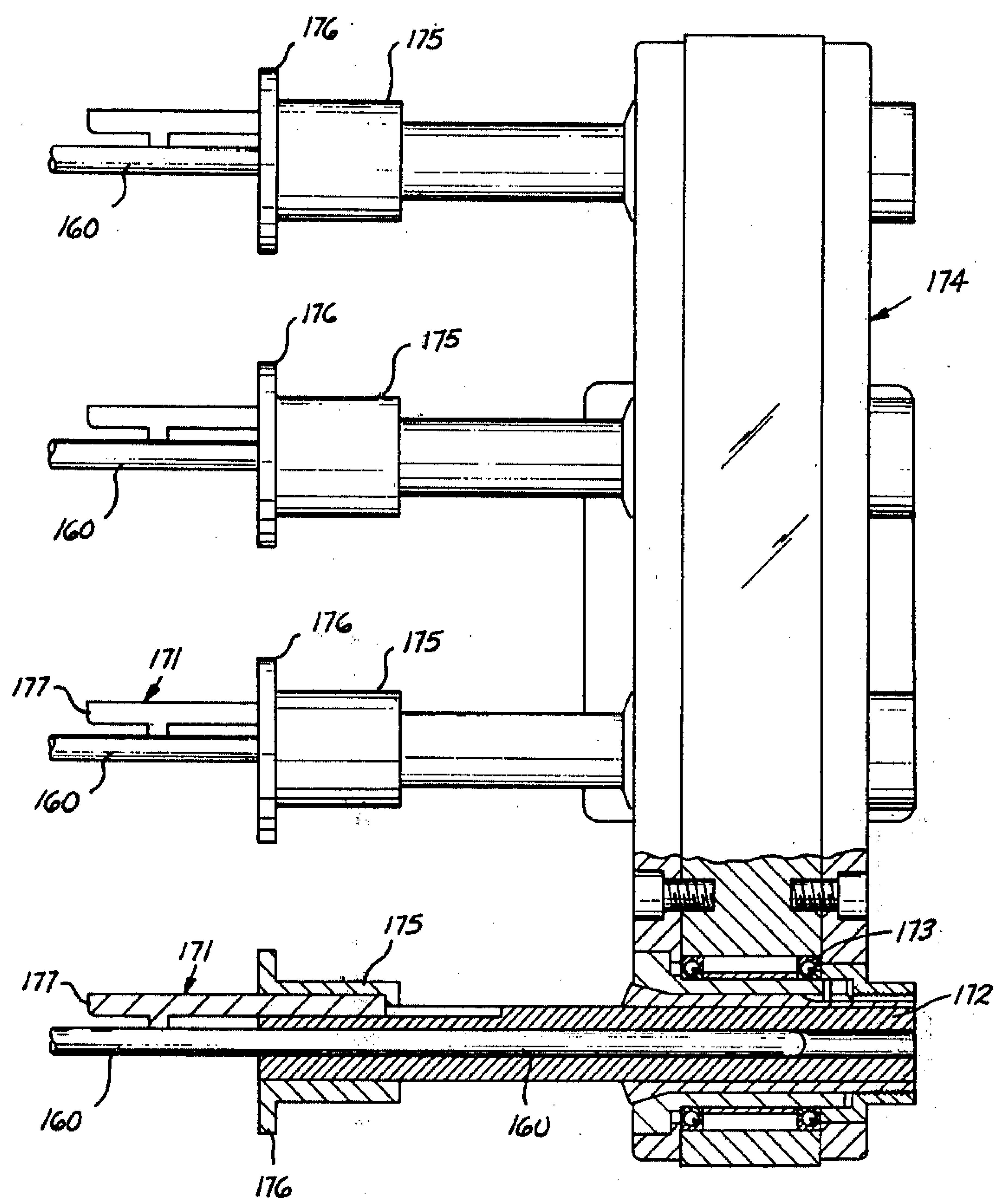
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FIG. 5

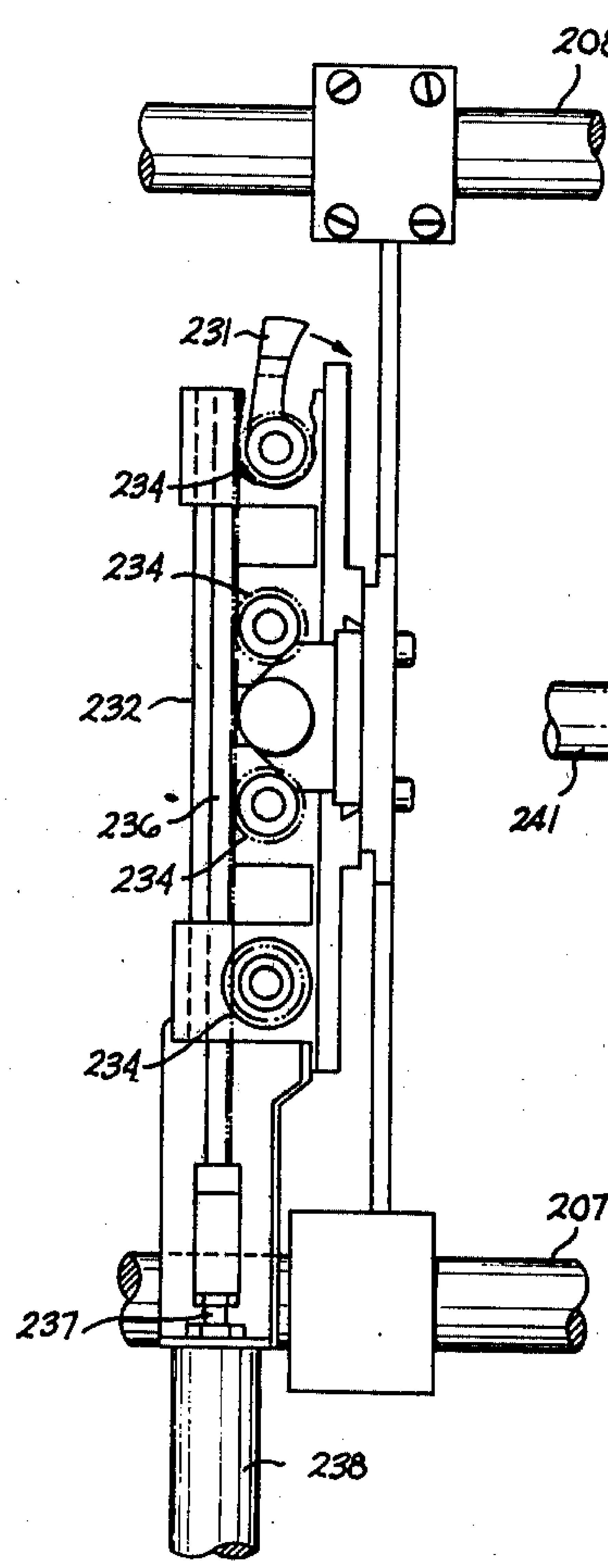
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FIG. 8

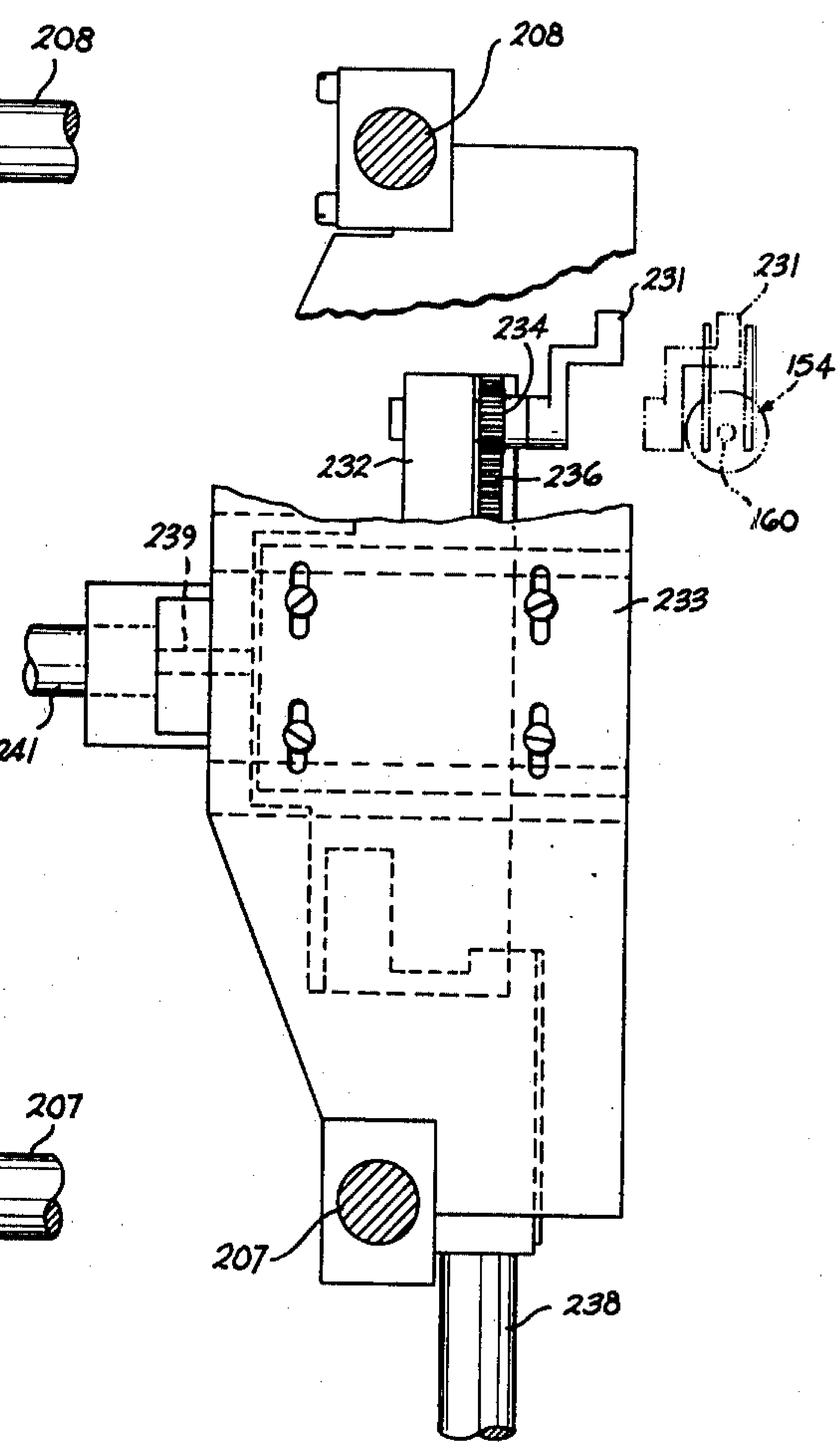
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FIG. 7

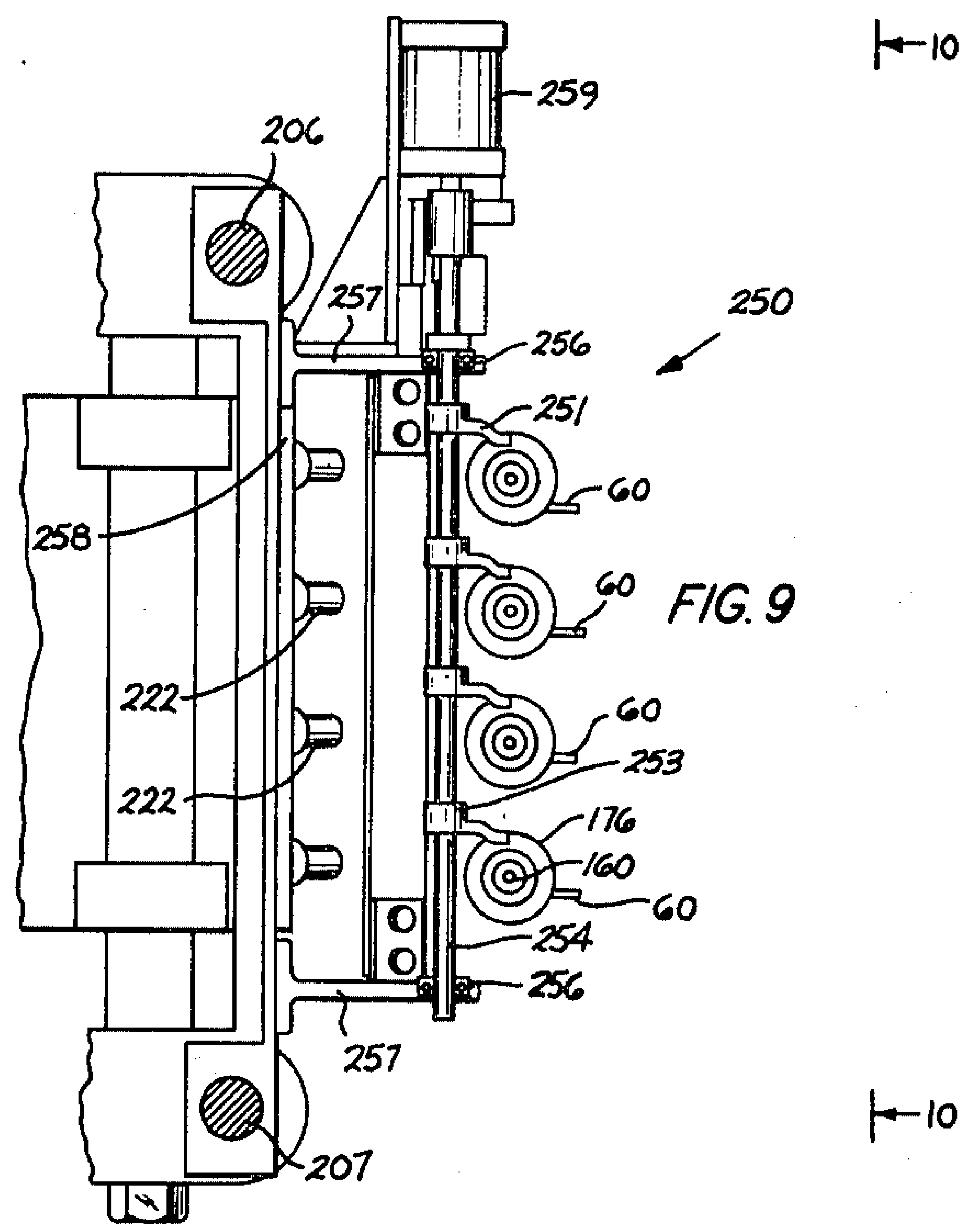
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FIG. 9

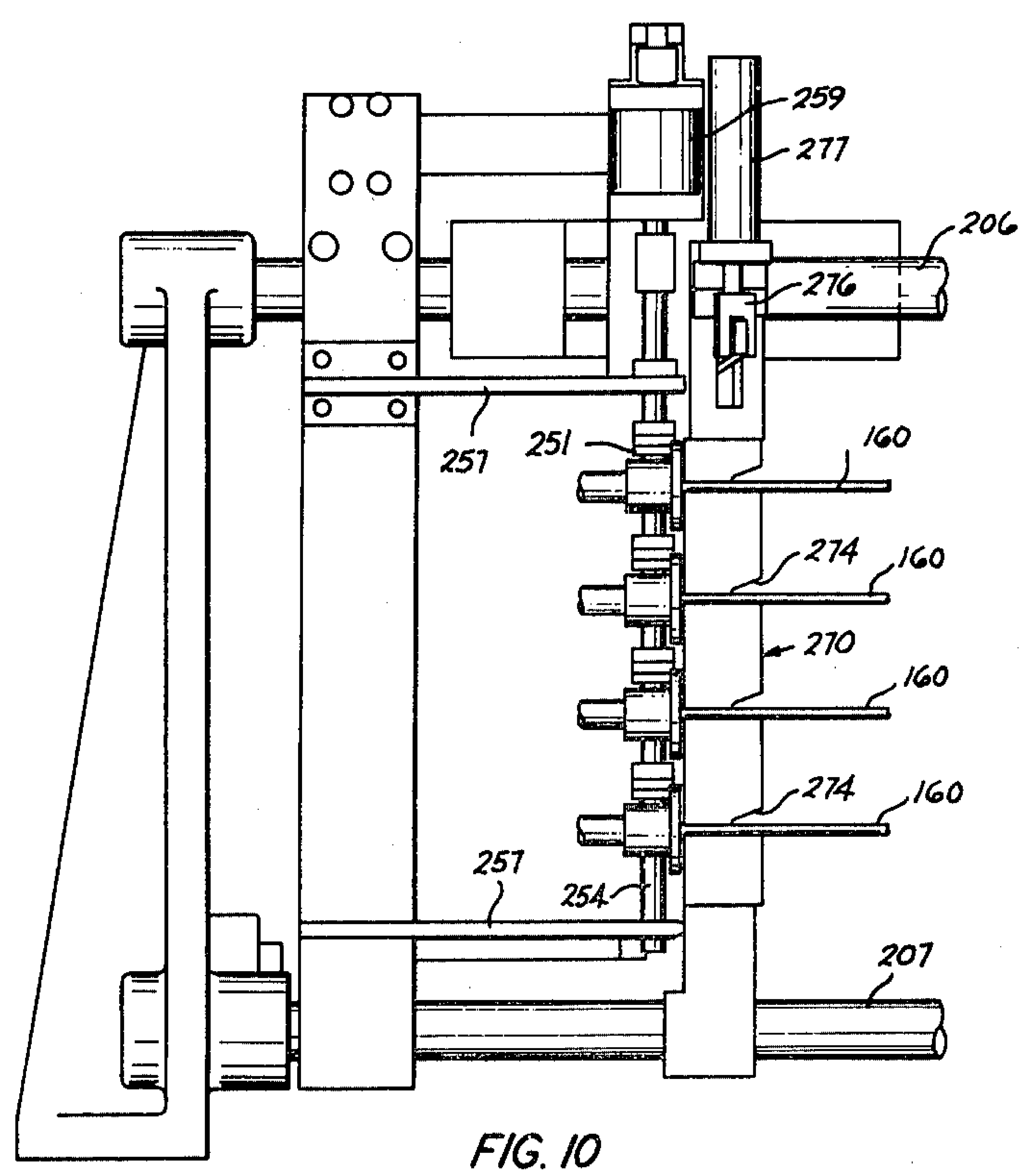
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FIG. 10

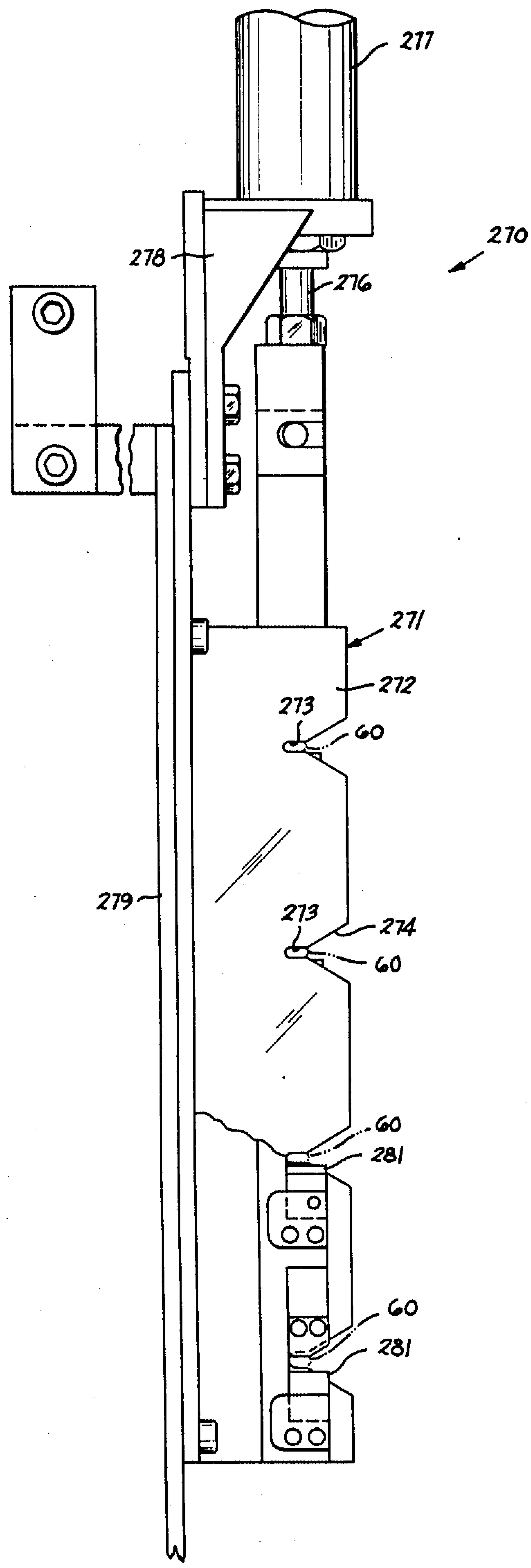

FIG. 11

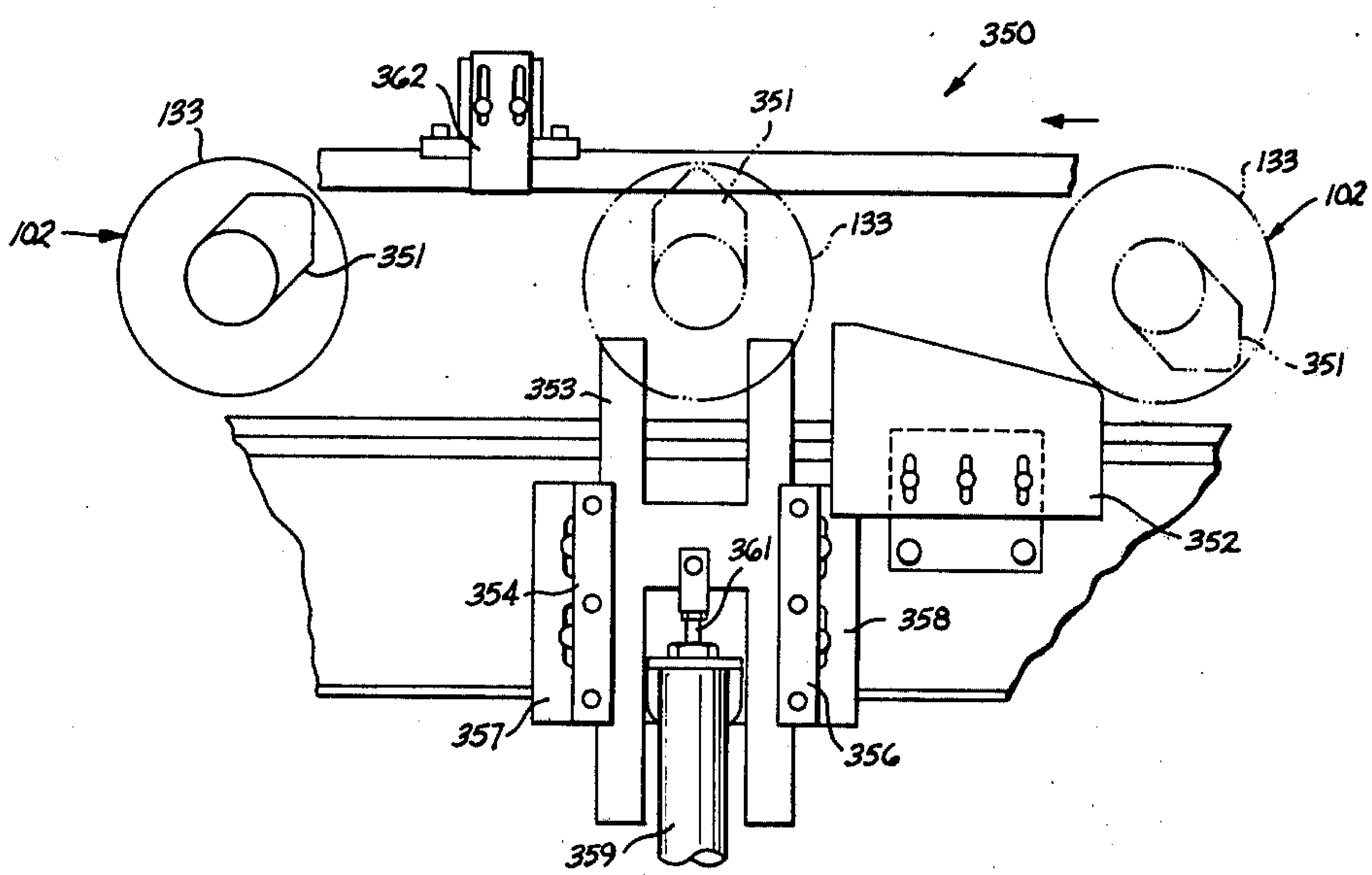
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FIG. 12

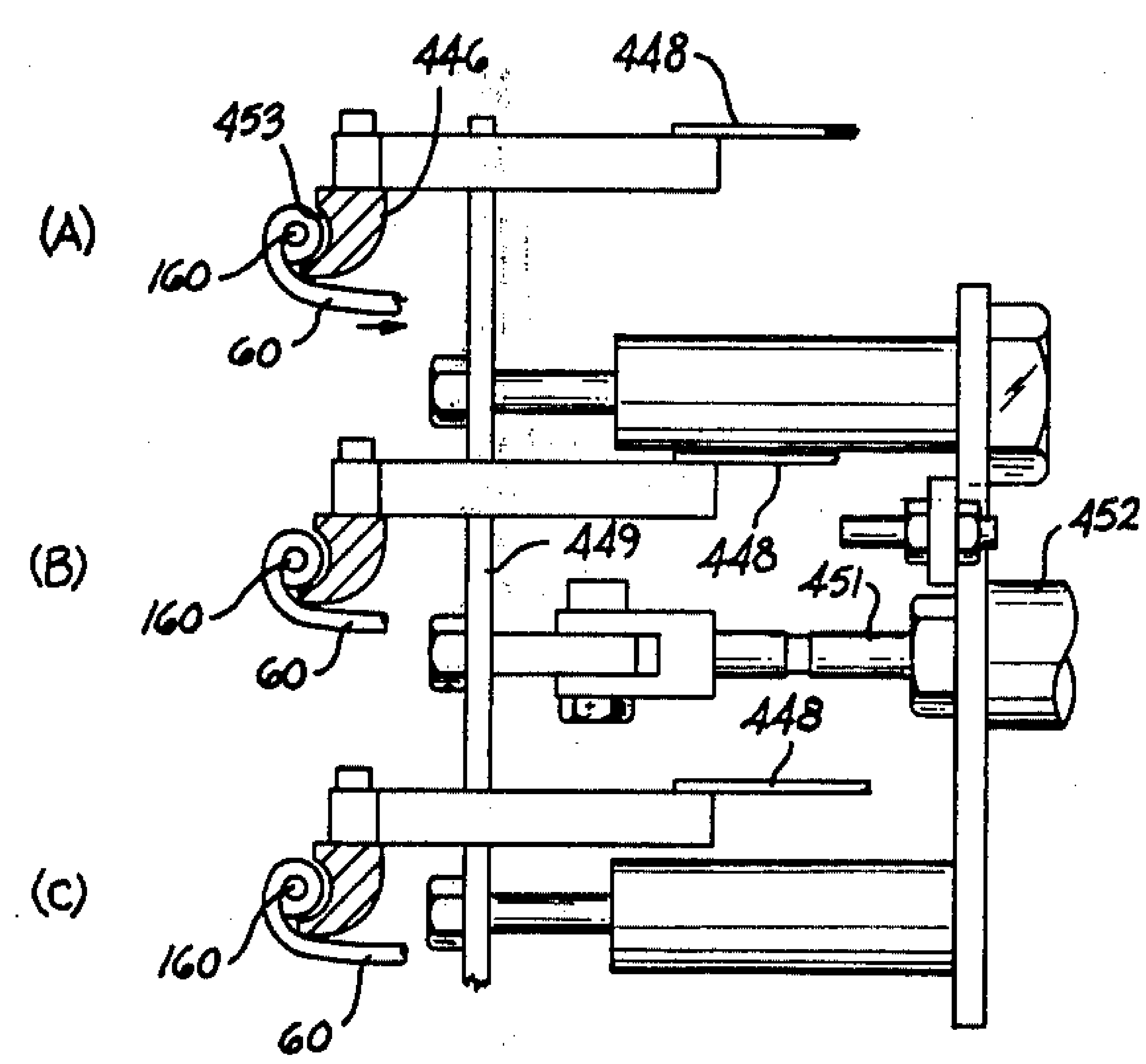
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FIG. 16

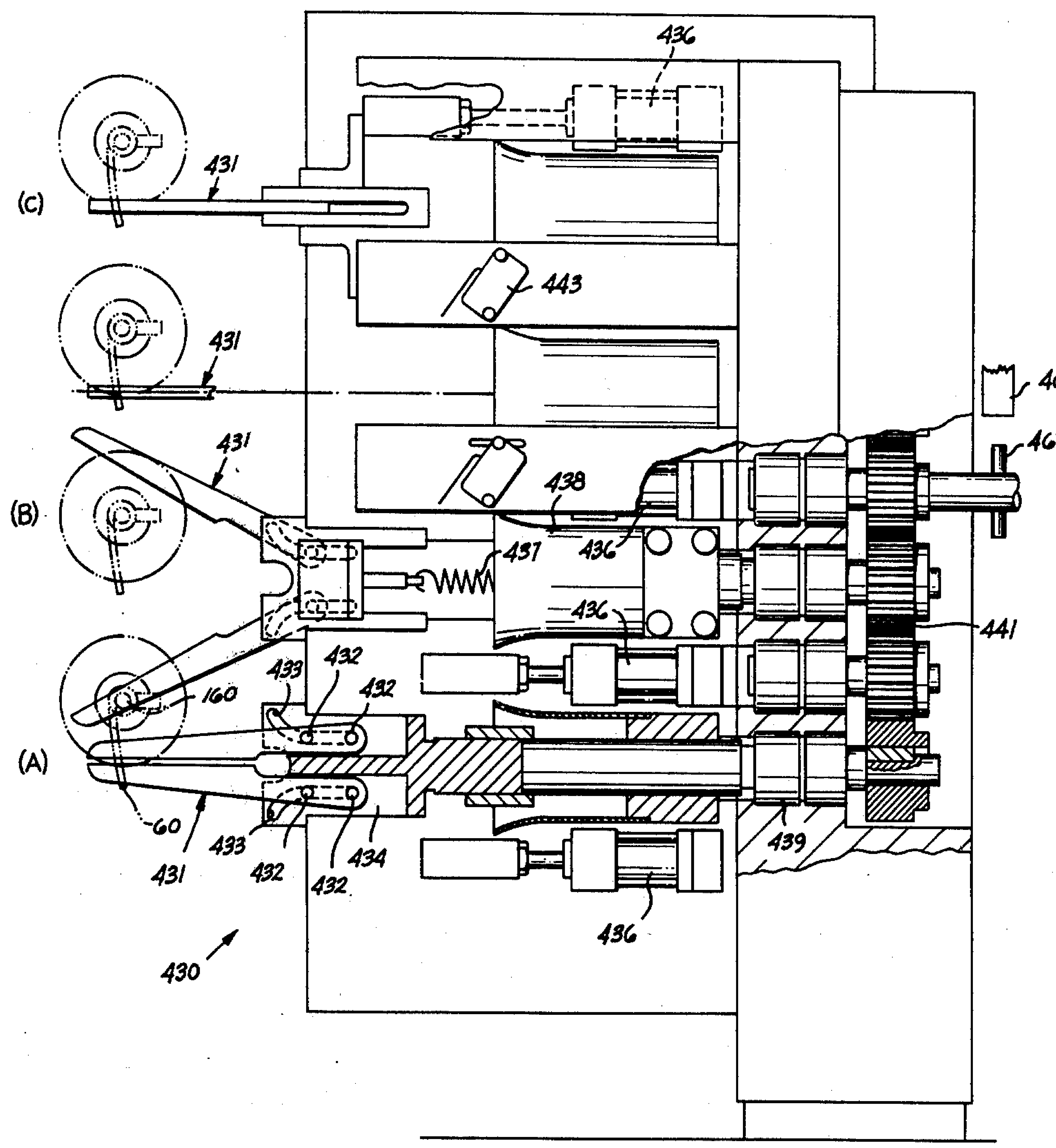
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FIG. 13

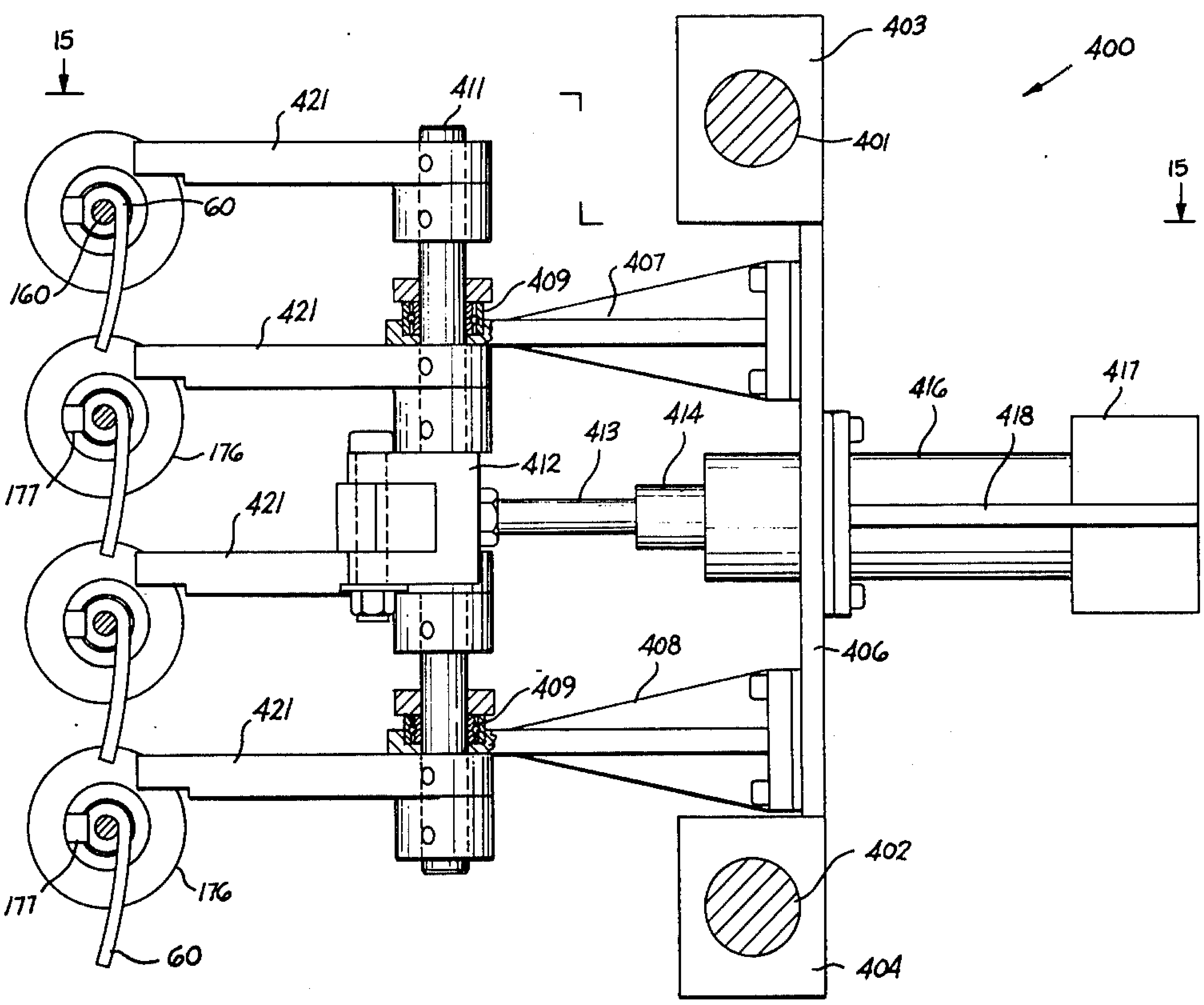
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FIG. 14

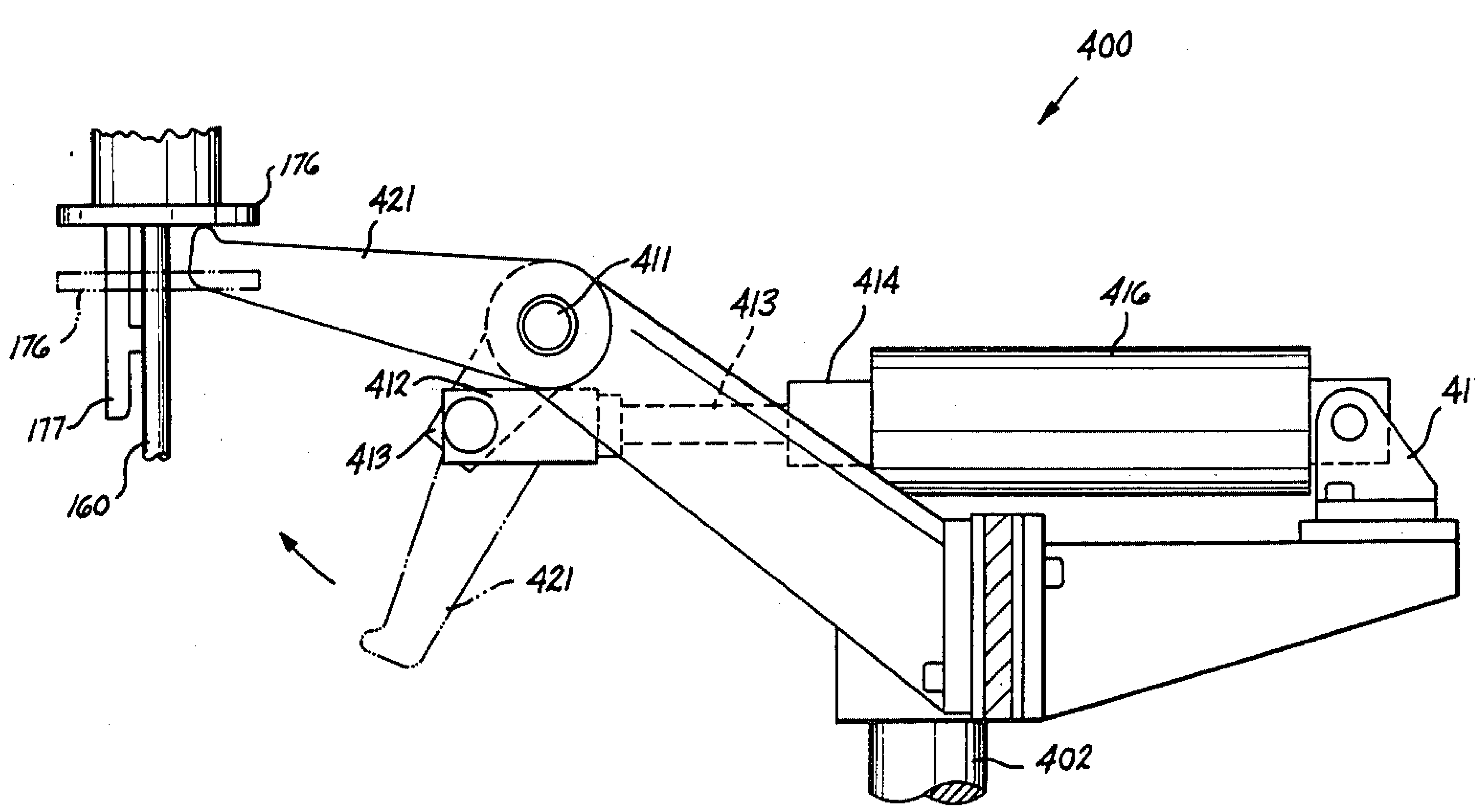
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FIG. 15

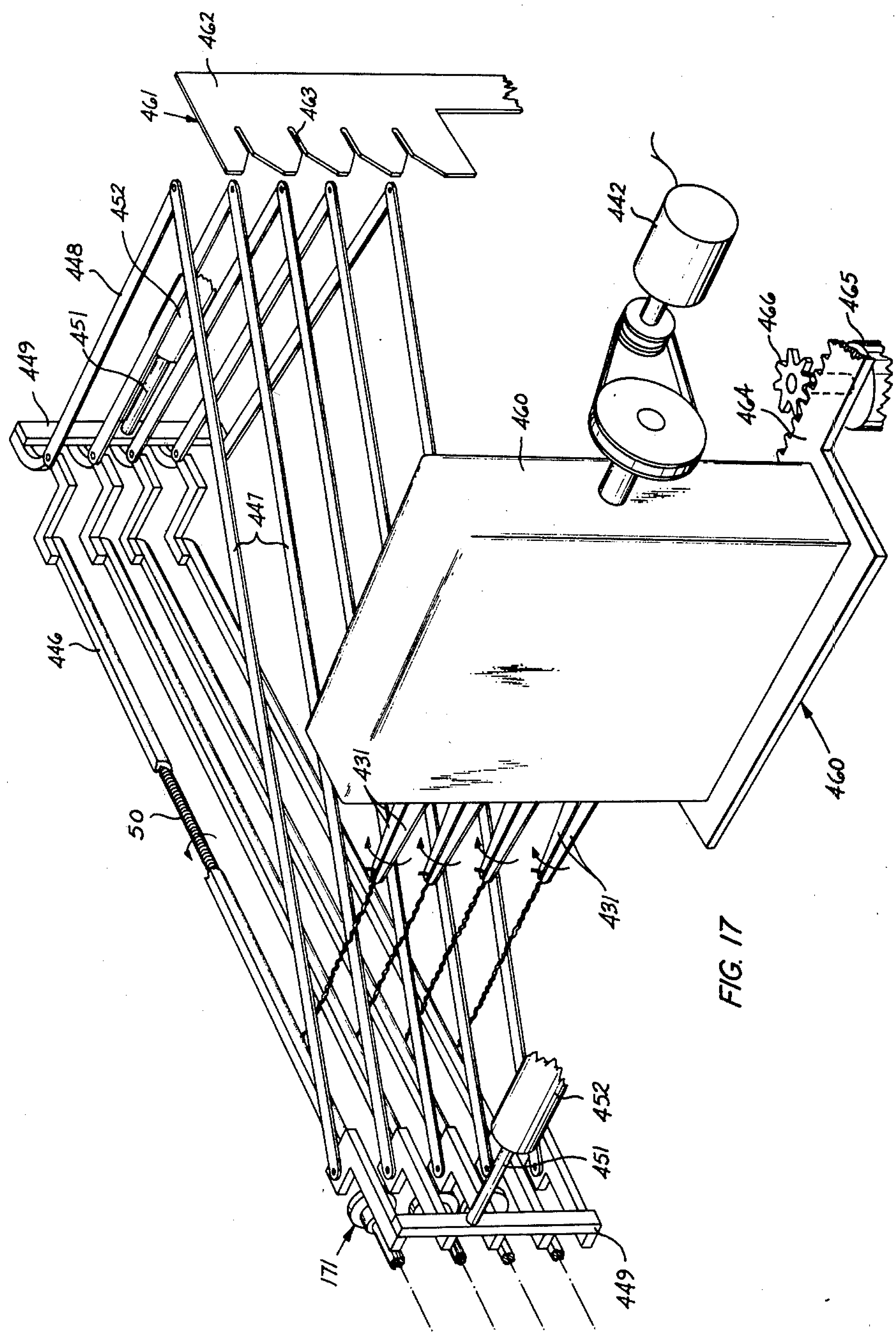
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FIG. 17

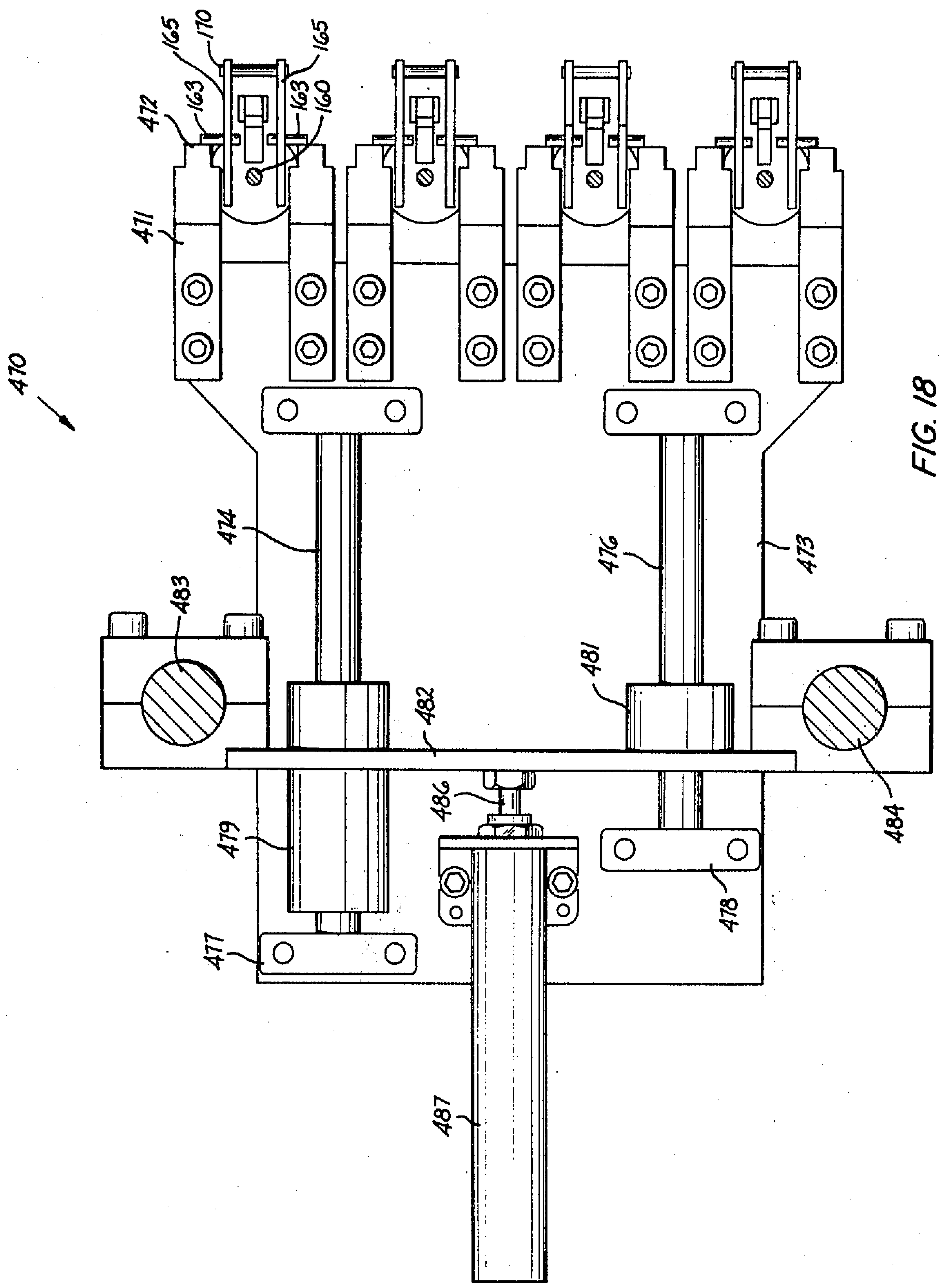
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FIG. 18

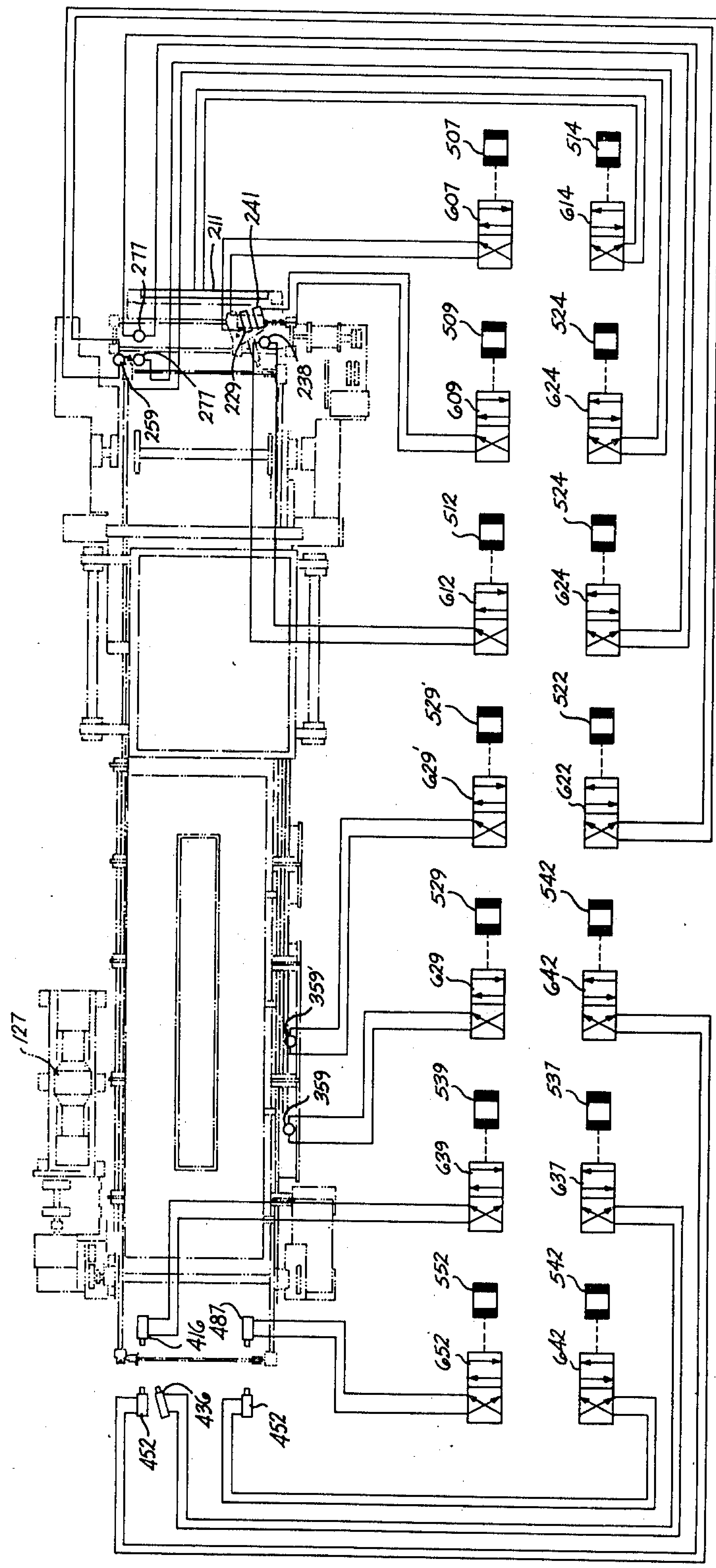

FIG. 20

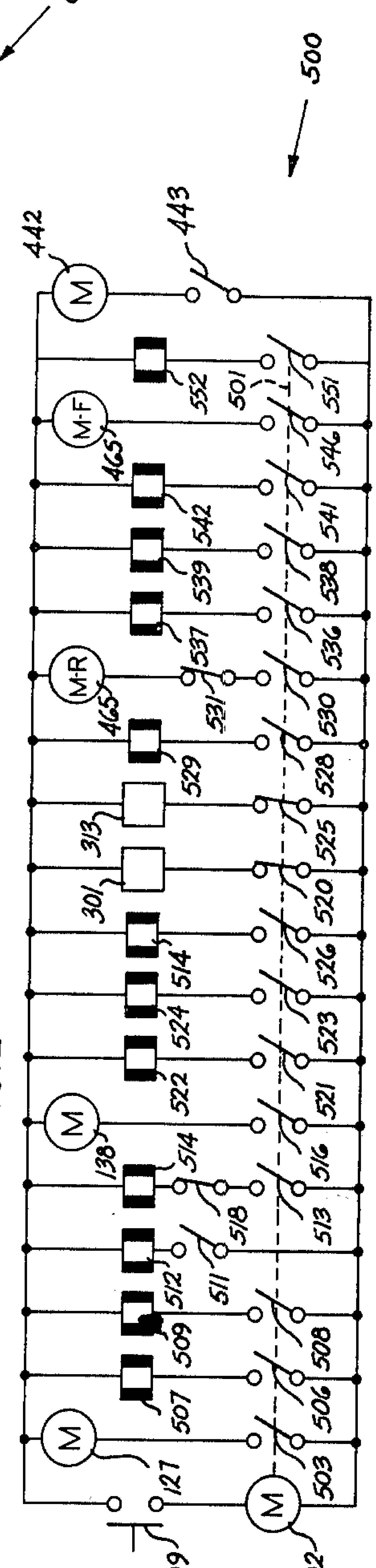

FIG. 19

METHOD OF MAKING RETRACTILE CORDS

CROSS-REFERENCE TO RELATED APPLICATIONS

The instant application is a division of application Ser. No. 641,003, filed on Dec. 15, 1975, now U.S. Pat. No. 3,988,092.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the method of making of retractile cords, and more particularly, to methods for the automatic manufacture of telephone cords wherein cordage is drawn from a supply, is fed into an apparatus and is conveyed through a plurality of the apparatus so that it emerges therefrom as a retractile cord adaptable for subsequent end finishing.

2. Description of the Prior Art

Retractile telephone cords, commonly referred to as spring cords, are widely used in the communications industry. For example, retractile cords are used to connect the handset of a telephone instrument to the telephone base. The spring cord is manufactured with the major portion thereof in the form of a compact helical cord, which may be extended by slight tension and which will return to the compact form when the tension is relieved.

The process of manufacturing spring cords by manual operation is well known and is described, for example, in U.S. Pat. No. 3,024,497 issued on Mar. 13, 1962 to E. C. Hardesty and D. L. Myers; the structure of the retractile cord is shown, for example, in U.S. Pat. No. 3,037,068 issued on May 29, 1962 to H. L. Wessel; and cord manufacturing apparatus is shown in E. L. Franke, Jr. U.S. Pat. No. 2,920,348 issued on Jan. 12, 1960, all incorporated by reference hereinto.

Generally, the manufacture of spring cords in the past has involved an operator who coils cordage from a fixed feed-in point onto a longitudinally moving mandrel after which the operator stacks a plurality of the mandrels in a rack which is conveyed in succession through an oven and a cooling chamber. Subsequently, the operator places each of the mandrels in an apparatus and then removes the cord from the mandrel while reversing the pitch of the helices of the cord to cause the spring cord to have a permanent and improved retractility.

Improved methods for stretching a spring cord by controlled varying amounts during helix reversing and overtwisting operations are disclosed in U.S. Pat. No. 3,087,199 issued on Apr. 30, 1963 to E. L. Franke, Jr. et al.

It is known to remove heat-treated spring cords from associated mandrels and to reverse the pitch of the helices of the coils by mounting a plurality of mandrels vertically and rotatably in a spaced-parallel array. A reciprocally movable carriage having a plurality of spindles rotatably mounted thereon is supported from a frame with each of the spindles aligned with an associated one of the mandrels. The carriage is moved from the mandrel to unwind the spring cords from the associated mandrels. Simultaneously, the spindles may be rotated in such a manner as to reverse the pitch of the helix of the spring cords being unwound from the mandrels.

As the carriage is moved relative to the mandrel to uncoil the cord, successive sections of the cord are moved axially, horizontally, and generally perpendicular to a stationary plate positioned between the mandrel and the carriage so that portions of the cord adjacent to the trailing end thereof are moved into and pulled through an associated slot formed in the plate. As the trailing end of the cord is disengaged from the mandrel, the last few convolutions of the cord spring together and expand radially on the mandrel-side of the plate thereby preventing the cordage from being pulled further through the slot. This is effective in retaining the last few convultions of the cords on the mandrel-side of the plate to maintain the cords unentangled and strung out between the spindle and the plate to facilitate removal. See U.S. Pat. No. 3,656,516 issued Apr. 18, 1972 in the name of E. C. Hardesty.

There have been attempts to construct an apparatus which may overcome the many manual steps involved in the well known techniques of making spring cords. For example, see U.S. Pat. Nos. 2,173,096, 2,525,285, 2,547,356, 2,718,660, 2,804,647. See also U.S. Pat. No. 2,898,630 issued Aug. 11, 1959 to G. P. Adams.

In U.S. Pat. No. 3,226,767, a leading end of cordage is attached to a mandrel which is then rolled along a magnetic track while winding convolutions on the mandrel. Subsequently, the mandrel is advanced through a heating zone, which comprises radiant heating elements or other heating means such as banks of infrared bulbs or facilities for induction heating of the mandrel. The mandrel is conveyed through a cooling zone and then to a reverse removing station whereat a released end of the coiled cordage is inserted into an unwinding mandrel with the mandrels driven in opposite directions to unwind the cord from one mandrel and reverse coil it onto the other. The reverse-coiled cord is removed from the mandrel by an axially sliding movement of the length toward and past the free end of the mandrel. See also U.S. Pat. No. 3,184,795, which interposes a blade-like member between adjacent ones of the convolutions being wound on a longitudinally moved mandrel to space the convolutions.

It has long been desired to provide a method which may be used to produce retractile cords at a high rate of production with the use of minimum floor space in order to realize manufacturing economies and to produce uniformly coiled heatset cords having uniform characteristics.

SUMMARY OF THE INVENTION

With these and other objects in mind, the present invention contemplates the method of making of retractile cordage by advancing a leading end of each of a plurality of cordage supplies into clamping engagement with an associated mandrel included in a group of mandrels of a leading one of a plurality of workholders mounted on a conveyor. The cordage is wound in a plurality of spaced-apart convolutions on each mandrel in a cord-loading position after which the wound cordage is severed from the supply in a manner to preclude a pullback of the conductors within the jacket at the newly formed cord end. The group of coiled cords is indexed through a heating zone whereat the mandrels are preheated to supplement subsequent exposure of the wound cords to radiant heat with the spacing apart of the convolutions enhancing the efficiency of the heating. Simultaneously, the next successive one of the workholders is advanced into the cord-loading position where cordage wound on each of the mandrels.

The group of coiled cords is advanced successively through a cooling zone and to a remove-reverse station whereat the free end of each cord is grasped and moved laterally, obliquely of the associated mandrel. This causes the pitch of the helices to be reversed in a manner to minimize enlargement of the helices of the cord which improves the retractile properties of the cord. As the last few convulutions are removed from each mandrel, the cord is drawn through an associated slot of a plate. Since the enlarged helices are incapable of being drawn through the slot, the trailing end portion of each end engages the flat side of the plate as the cord springs from the mandrel and the trailing end is released from the mandrel and grasping mechanism.

More particularly, a leading end of each of a plurality of supplies of retractile cordage is advanced by a feeding mechanism into engagement with each of a plurality of clamping devices mounted on associated ones of a plurality of mandrel which are mounted in groups on an endless conveyor in parallel relationship. Following the clamping of the leading end of each of the cordage supplies with the associated mandrel, the feeding mechanism traverses the mandrels to coil a predetermined number of spaced-apart convulutions on each mandrel in a cord-loading position. Following the coiling, the last convolution is secured to its associated mandrel and each of the wound cords is severed from the associated supply by a cutting device such that the conductors of the new leading end of each cordage supply are flush with the free end of the jacket. The group of coiled cords are then indexed through a heating station in which the mandrels are preheated inductively to heat the inwardly facing surfaces of the convolutions of each cord. Subsequently, the group of mandrels is indexed through a portion of the heating station where radiant heat is applied to the outwardly facing surfaces of the convolutions. While the heating of the initial group of mandrels and cordages is occurring, the next successive group of mandrels in the cord-loading position is in the process of having cordage wound thereon. The group of coiled heated cords is then advanced successively through a cooling station, oriented and then advanced to a remove-reverse station. At the remove-reverse station a plurality of grasping jaws engage trailing ends of the cords wound on the associated mandrels. The grasping jaws are then moved as a group transversely obliquely of the axes of the mandrels thereby causing the convolutions to be unwound from the mandrels. Simultaneously, the mandrels are rotated individually in a direction such that the rotation thereof together with the rotation of the grasping jaws causes a reversing of the pitch of the helices. The removing and the reversing is accomplished with the successive sections of each cord being advanced past a device which controls the pulling forces applied to the cord to minimize any enlargement of the helices. The last few convolutions of each cord are caused to be guided through an associated slot of a plate such that the trailing end portion of each of the cords engages the flat side of the plate as the trailing end is released from its grasping jaws. This causes the cord to be caught and retained to facilitate removal from the apparatus by an operator.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and features of the present invention will be more readily understood from the following detailed description of specific embodiments thereof when read in conjunction with the accompanying drawings, in which:

FIG. **1** is an elevational view illustrating an apparatus for carrying and the methods of this invention for manufacturing retractile cords;

FIG. **1**(A) is a perspective view of a retractile cord and showing details of the structure thereof;

FIG. **2** is a perspective view of a mandrel with the cord wound thereon and showing facilities for clamping each end of the cord and the orientation of facilities in a heating station relative to the mandrel for preheating the mandrel;

FIG. **3** is a plan view taken along lines **3—3** of FIG. **1** and showing details of a cord-coiling position of the apparatus of FIG. **1**;

FIG. **4** is an end elevational view taken along lines **4—4** of FIG. **3** partially in section and showing one end of a group of mandrels which comprise one of a plurality of workholders mounted on an endless conveyor with a portion FIG. **4**(A) further showing three of the four mandrels of the group in an unoperated position for clamping a leading end of cordage to be wound on the mandrel and a portion FIG. **4**(B) showing the clamping facilities of the fourth mandrel in an operated position for purposes of clarity;

FIG. **5** is an end elevational view taken along lines **5—5** of FIG. **3** and showing the other end of each of the group of mandrels of the workholder in the cord-coiling position with facilities for clamping the trailing end of the cordage;

FIG. **6** is a detail view of one of a plurality of feed nozzles for feeding a supply of cordage into engagement with an associated mandrel in the cord-coiling position;

FIGS. **7** and **8** are side and end elevational views, respectively, of facilities in the cord-coiling position for acutuating the facilities for clamping the leading ends of the cordage;

FIG. **9** is a side elevational view taken along lines **9—9** of FIG. **3** and showing facilities for operating the facilities for clamping the trailing ends of the wound cordage;

FIG. **10** is an end view taken along lines **10—10** of FIG. **9** and showing further the facilities for actuating the trailing end clamping facilities and facilities for severing the wound cordage from the associated supplies;

FIG. **11** is an enlarged elevational view of the cordage severing facilities;

FIG. **12** is a detail view in elevation and showing a device for orienting each successive group of mandrels to facilitate removal of the cords therefrom;

FIG. **13** is an enlarged view of a portion of the facilities for removing the cords from the mandrels and for reversing the pitch of the helices thereof with one of the devices associated with each of the mandrels of a workholder at that workstation, wherein position (A) is an enlarged view of a device for grasping the trailing end of an associated aligned wound cord, position (B) is a view of the device in position (A) with the device in an open position, and position (C) is a view of the device in position (B) relative to the associated cord wound on the associated mandrel;

FIG. **14** is a view showing facilities for releasing the clamping facilities at the trailing end portions of the wound cordage;

FIG. **15** is a view of the facilities of FIG. **14** taken along lines **15—15** thereof;

FIG. 16 is an enlarged view of a plurality of stripper bars in the cord-removal position for facilitating the removal of the cords with minimum pulling forces;

FIG. 17 is a perspective view of the cord removal and reversing facilities;

FIG. 18 is a side elevational view of a portion of the removal facilities and showing a device for releasing the cord-leading end clamping facilities;

FIG. 19 is an electrical control circuit for the apparatus; and

FIG. 20 is a schematic view showing a pneumatic control system for the assembly apparatus.

DETAILED DESCRIPTION

Product Produced by Methods

Electrical retractile cords which are used in connecting, for example, portions of a telephone instrument are shown for example, in U.S. Pat. Nos. 2,413,715 and 3,553,042. An electrical retractile cord **50** (see FIG. **1**(A)) which is to be manufactured in accordance with the methods of this invention includes a plurality of individually insulated conductors **51—51**. Each conductor **51** includes a center core **52** made, for example, of nylon and has a tinsel ribbon **53** wrapped thereabout. The ribbon **53** has a layer of insulation **54** extruded thereover. The plurality of conductors **51—51** are jacketed with an insulative covering **56**, which typically is polyvinyl chloride, to provide a flat cord **50** having a cross section in which the sides are parallel joined by generally semi-circular end sections.

Typically, the inner diameter of the convolutions of the retractile cord **50** is approximately 0.375 inch. The major distance across the cross section of the jacketed conductors, which comprise the cord cross section is approximately 0.20 inch.

In a process for continuously automatically manufacturing retractile cords, commonly referred to as spring cords, a desired length of jacketed, multiconductor cordage **60** from a supply **61** is wound in a helix along the length of a rotating and longitudinally moving mandrel **160**. The cord is heated on the mandrel **160** to a temperature above the softening point of the jacketing composition, to relieve strains in the jacketing material and to impart a helical set to the cord after which the cord **50** is cooled to room temperature. After cooling, the heat-treated cord **50** is removed from the mandrel **160** and the pitch of the helix is reversed in order to provide a spring cord having greater retractility. See U.S. Pat. Nos. 2,920,348, 2,920,351 and 3,087,199, exemplary prior art.

Overall

An apparatus for performing the method which embodies the principles of this invention is designated generally by the numeral **100** and is shown in FIG. **1**. The apparatus **100** includes an endless conveyor, designated generally by the numeral **101** and having a plurality of workholders **102—102**. The conveyor **101** is mounted on a frame **103** to advance each of the workholders **102—102** through a pluraluty of work stations which include in seriatim, a cord-coiling station **104**, a workholder preheat station **105**, a cord-heating station **106**, a cord-cooling station **107**, a workholder-alignment station **108**, and a cord remove-reversal station **109**.

Conveyor and Workholders

As can be seen in FIG. **1**, the conveyor **101** is comprised of a plurality of links **121—121** which are interconnected through the workholders **102—102** in an endless path and supported about portions of the peripheries of spaced sprockets **122** and **123**. The sprockets **122** and **123** are mounted rotatably on shafts **124—124** supported in bearings **126—126** which are held in the frame **103**. A plurality of interconnected sprockets **128—128**, which comprise the conveyor **101** are adapted to be indexed through an incremental distance by a motor **127** (see FIG. **20**) mounted on the frame **103** and connected through appropriate linkage to one of the sprockets **122** and **123**.

Referring now to FIG. **3**, it can be observed that each adjacent pair of links **121—121** are pin-connected to a drive head **130** of one of the workholders **102—102**. The head **130** includes a bearing **131** (see FIG. **4**) having a drive shaft **132** extending therethrough with an outer end thereof connected to a sprocket **133**. The sprocket **133** is adapted to be engaged by a clutch face **134** which is turned rotatably by a belt **136** passed around a pulley **137** of a motor **138** (see FIG. **1**).

Turning now to FIGS. **3** and **4**, it can be seen that the drive shaft **132** mounted rotatably in the bearing **131** extends into the head **130** and is attached to a main gear **141** and has the other end thereof received in a bearing **142**. The main gear **141** is intermeshed directly with a first pair of drive gears **143—143** which are associated with bearings **144—144**, and through a pair of secondary gears **146—146**, which are supported in bearings **147—147**, to a second set of drive gears **148—148** that are aligned with bearings **149—149**.

A separate shaft **151** extends through each of the gears **143—143** and **148—148** and then extends through each of the aligned associated bearings **144—144** and **149—149** and then externally of the head **130**. Each of the shafts **151—151** supports one end of apparatus on which the cord **50** is to be coiled. Since the inner end of each of the shafts **151—151** is attached to the associated one of the gears **143—143** and **148—148**, the rotation of the gears through the gear drive train causes the shafts **151—151** to be turned rotatably.

In order to describe one of the coiling apparatus, reference is made to FIG. **4**. The end of each of the shafts **151—151**, which extends from the head **130**, is received in a stepped bore **152** of a housing **153** of a toggle clamp assembly, designated generally by the numeral **154**. The shaft **151** is held within the housing **153** by a fastener **156** engaging a necked-down portion **157** of the shaft **151**. In the other end of the stepped bore **152**, there is received in a press fit one end of a mandrel **160** on which the cordage is to be coiled.

The toggle clamp assembly **154** has provisions for clamping a leading end portion of cordage which is wound on the mandrel **160**. A pair of spaced crank arms **161—161** (see FIGS. **2** and **4**) are mounted pivotally to a bifurcated portion **158** of the housing **153** of the toggle clamp assembly **154** by a shaft **162** with one end **159** of each of the arms having a stud **163** extending laterally thereof. Further, as can be seen by the lower one of the toggle clamp assemblies in FIG. **4**, a link **164** is connected to the shaft **162** and pin connected to a second H-shaped link **166**. The H-shaped link **166** is pinconnected to an L-shaped lever **167**, which is mounted pivotally to the housing **153** by a pin **168**. An end **169** of the lever **167** is effective to clamp to a leading end of the cordage in engagement with the mandrel **160**. Opposite ends **165—165** of the arms **161—161** are connected together by a pin **170**.

The opposite end of each mandrel **160** extends through an end-of-coiling clamp assembly, designated generally by the numeral **171** (see FIGS. **2** and **5**) into a sleeve **172** mounted rotatably in a bearing **173** of a support head, designated generally by the numeral **174**. The support head **174** is interconnected to adjacent ones of the plurality of links **121—121** on the opposite side of the conveyor **101**.

The clamp assembly **171** has a portion **175** thereof adapted to be moved slidably with the sleeve **172** relative to the mandrel **160** and includes a flanged hub **176** having the one portion **177** which extends beyond the end of the sleeve. The portion **177** of the clamp assembly **171** is adapted to be moved to an operative position such that the portion **177** is moved over a last one or ones of the convolutions. As this occurs, severing facilities to be described hereinafter are controlled to form a trailing end of the cordage **60**. Because of its resilience, the newly formed trailing end of the cordage **60** which initially extends to the left, as viewed in FIG. **9**, toward the associated supply **61**, whips about the mandrel **160** in a counterclockwise direction until it extends to the right as viewed in FIG. **9**. This orientation becomes important during the subsequent remove-reversing process. It is also well to recall that the leading end of the cordage (see FIG. **2**) extends in the same direction as the trailing end thereof.

Cord Coiling

An apparatus, designed generally by the numeral **200**, is provided in the cord-coiling station **104** for coiling cordage from each of a plurality of supplies onto a plurality of the mandrels **160—160** associated with each of the workholders **102—102**, which are advanced into the cord coiling station. It should be observed from FIG. **4** that the mandrels **160—160** of the workholder **102** in the cord-coiling station **104** are parallel and aligned in a vertical plane.

The cord-winding or cord-coiling apparatus **200** includes a cordage-feeding device **201**, which is best seen in FIGS. **3** and **6**. The cord-feeding device **201** is mounted on a carriage **202**, which is supported slidably by a bracket **203** and a bracket **204** from parallel rods **206** and **207**, respectively. The rods **206** and **207** are mounted in end supports **208** and **209** which comprise the frame **103**. The carriage **202** is adapted to be moved along the length of the mandrels **160—160** of the workholder **102** in the cord-coiling position by a cable cylinder arrangement **211**. This facilitates the winding of spaced-apart convolutions of the cordage along the length of each of the mandrels **160—160**.

The carriage **202** includes a pair of spaced bearings **212—212** attached thereto for supporting slidably a rod **213**. The rod **213** also extends through a pair of spaced bearings **214—214**, which are attached to and movable with the rod. Further, one of the bearings **214—214** has a stud follower **216** upstanding therefrom and received in a cam slot **217**. As the carriage **202** is moved to the right by the cable cylinder **211** in FIG. **3**, the follower **216** is moved along the slot **217** and causes the rod **213** to be moved slidably within the bearings **212—212** from the mandrel **160**. This movement assumes importance during the severance of the wound cordage **60** from the supplies thereof.

The cordage feeding device **201** associated with each of the mandrels **160—160** is best seen in FIG. **6** and includes a housing **218** having a tube **219** with a flared inlet **221** at the cordage-input end and a feed nozzle **222** at the output end thereof. The feeding device **201** further includes an eccentrically mounted snubber **223**, which cooperates with a block **224** to prevent retrograde movement of the cordage **60**. The cordage **60** extends through the housing **221** between the block **224** and the snubber **223** and between an opposed pivotally mounted pawl **225** and an anvil **226**, which are adjustable to grip slightly the cordage between. It should be understood that since the cordage **60** is being pulled from barrel supplies **61—61**, there is a slight back tension on the cordage.

The pawl **225** and the anvil **226** are mounted at end portions of plates **227—227** which are movable reciprocally by a piston rod **228** of an air cylinder **229** that is operated to move the pawl **225** and the anvil **226** and hence the cordage gripped therebetween to the left as viewed in FIG. **6** into engagement with the associated mandrel **160**. A portion of the apparatus **200** to be described hereafter causes the lever **167** to be moved pivotally to cause the end portion **160** thereof to clamp the leading end portion of the cordage **60** in engagement with the mandrel **160**. Then the air cylinder **229** is operated to withdraw the rod **228** to the right as viewed in FIG. **6**. Since the pawl **225** and the anvil **226** are only in slight gripping engagement with the cordage **60**, they are moved easily to the right and further permit sections of the cordage to be fed therethrough for coiling onto the mandrel **160**.

In the alternative, the pawl **225** could be cammed open prior to a retrograde movement and then cammed closed prior to advancing the jaws to move the leading end into engagement with the mandrel **160**.

The portion of the apparatus **200** which causes the clamping of the leading end portion of the cordage **60** with the associated mandrel **160** is best seen in FIGS. **3**, **7** and **8**. A plurality of cranks **231—231** are mounted individually pivotally on a bar **232** which is attached to a plate **233** supported from the frame **103**. A pinion **234** is attached to the end portion of each of the cranks, which extend through the bar **232**.

In order to turn the cranks **231—121** in unison, a rack **236** is disposed in juxtaposition with the bar **232** so that the serrations (not shown) thereof intermesh with the gear teeth of the pinions **234—234**. The rack **236** is connected to a piston rod **237** extending from an air cylinder **238**. Operation of the air cylinder **238** causes the rack **236** to be moved upwardly, as viewed in FIGS. **7** and **8**, thereby moving rotatably the pinions **234—234** to turn pivotally the associated ones of the cranks **231—231**.

As will be seen in FIG. **3**, the crank arms **231-231** (which are aligned vertically in FIG. **1**) are spaced from the crank arms **161—161** of the associated mandrels **160—160**. In order to clamp the leading end portions of each supply of the cordage **60** with the associated mandrel **160**, the crank arms **161—161** must be turned clockwise as viewed in FIG. **4** by the cranks **231—231**. To facilitate the engagement of the cranks **231—231** with the crank arms **161—161**, the support plate **233** is attached to and supported from a piston rod **239** extending from an air cylinder **241**. The operation of the air cylinder **241** causes the plate **233** to be moved to the right as viewed in FIG. **7** to dispose the cranks **231-231** adjacent the associated ones of the crank arms **161-161**. Then the air cylinder **238** is operated to move slidaby the rack **236** to cause the above-described turning of the cranks into engagement with the portions **163—163** (see FIG. **4**) of the toggle clamp assemblies **154—154** and the accompanying clamping of the leading end portions of the cordages 60—60.

Following the severing of the leading end portions of each supply 61 of the cordage 60 in engagement with the associated mandrel 160 in the cord-loading station 104, the carriage 202 is caused to be moved along the rods 206 and 207 to wind a plurality of spaced-apart convolutions of cordage on each mandrel. Preferably, the adjacent convolutions are spaced apart approximately 0.040 inch with the convolutions being on approximately center to center or pitch distances of 0.240 inch. The spacing apart of the convolutions advantageously improves the heating and the cooling of the wound cords 50—50 by exposing the curved side surfaces of the so-called flat cords. Moreover, the spacing is important in preventing the undesired sticking together of adjacent convolutions thereby facilitating the removal of the cords 50—50 from the mandrels 160-160.

The spacing apart of the convolutions of the cords 50—50 is accomplished by coiling a predetermined number of convolutions on each of the mandrels 160-160 by a predetermined velocity of traverse of the carriage 202 along the rods 206 and 207 in cooperation with a predetermined rotation of each of the mandrels.

Further, the cord-coiler apparatus 200 includes a device, designated generally by the numeral 250 and best seen in FIGS. 9 and 10, for causing the clamp assembly 171 to engage the newly formed trailing end portion of the wound cordage. A plurality of forked fingers 251—251 and end fingers 252—252 extend from bushings 253 connected to a vertical shaft 254 which is rotatably mounted on spaced bearings 256—256 held in brackets 257 cantilevered out from a portion 258 of the frame 103 in which the rods 206 and 207 are supported. An upper end of the shaft 254 is operatively connected to a rotary air cylinder motor 259 such as one available under the designation "ROTAC". The operation of the motor 259 causes the shaft to be turned through ninety degrees to move the fingers 251 and 252 into engagement with the hubs 176—176 of the associated double clamp assemblies.

The completion of the turning of the shaft 254 causes the end portions 177—177 of the hubs 176—176 to be moved over the last one or ones of the convolutions of the wound cordage 60 on the associated mandrels 160—160. Then the severence of each wound cordage 60 from the supply thereof results in a cordage 60 wound on the associated mandrel 160 with the leading end thereof held in engagement with the mandrel by the end 169 of the lever 167 (see FIG. 4) and the last one or ones of the convolutions captured held under the associated portion 177 of the hub 176.

Following the completion of the traverse of the carriage 202 along the rods 206 and 207 to the extreme right position shown in FIG. 3, and the operation of the clamp assemblies 170—170, it becomes necessary to sever the cordage 60 wound on each mandrel 160 from the supply thereof with each newly formed trailing end in engagement with its associated mandrel. As can be seen in FIG. 3, the housing 221 of the cord-feeding device 201 has been moved in a retrograde direction to the position shown in phantom when the carriage 201 has completed the traverse of the mandrels 160—160.

The severance of the cord 50 associated with each mandrel 160 from the supply 61 thereof is accomplished by the apparatus shown in FIG. 11 and designated generally by the numeral 270. The severing apparatus 270 includes two similarly constructed severing devices 271—271 each of which includes a slidably mounted plate 272 having a plurality of cordage receiving slots 273—273 formed therein with each slot having a flared opening 274.

The plate 272 is attached to a piston rod assembly 276 extending from an air cylinder 277 mounted on a bracket 278 attached to a portion 279 of the general frame 103. A plurality of blades 281-13 281 are attached to a plate, which is stationary, is connected to the portion 279 of the frame 103, and which is essentially contiguous the moveable plate 272. With cordage 60 associated with each cord 50 extending through each of the slots 273—273, the movement of the plate 272 by the air cylinder 277 causes the blades 281—281 to sever the cordage.

It was mentioned hereinabove that the apparatus 270 included two cordage-severing devices 251—251 disposed adjacent one another with the cordage 60 extending between aligned slots 273—273 of the plates 272—272 of the associated devices. Dual severing devices 271—271 are used to avoid problems associated with what is referred to in the art as "suck-back". The severance of cordage under some slight tension will cause the conductors 51—51 to be moved slidably within the cord structure relative to the jacket such that the severed ends of the conductors are not contiguous to or flush with the severed end of the jacket. This undesired withdrawal or foreshortening of the conductors 51—51 occurs because of the development of tension in the cordage 60 as it is being wound on the mandrel 160. Hence, if the newly thus-formed leading end of the cordage was clamped to the associated mandrel in the next cycle of operation, an operator would have to separate that end portion of the jacket 56 extending beyond the conductors 51—51 prior to end finishing of the wound cord 50.

By using two of the devices 271—271, each of the wound cords 50—50 is severed from the supply in a delayed sequence of operation of the first of two air cylinders 277—277 after which the second air cylinder is operated to sever the cordage at a second location spaced a predetermined distance upstream from the first line of cut. The delay in time between the operation of the air cylinders 277—277 provides the necessary time for "suck-time" to occur. The predetermined distance is sufficient to separate out the portion of the jacket which has been vacated by the "suck-back" of the conductors. If the cylinders were operated simultaneously, the conductors 51—51 would withdraw disadvantageously within the newly formed leading end.

Cord Heating

Subsequent to the coiling of cordage 60 on each group of the mandrels 160—160, the conveyor 101 is indexed to advance each group in a counterclockwise direction, as viewed in FIG. 1, through dual heating stations 105 and 106. The heating stations 105 and 106 extend over six step positions on the conveyor 101 and include apparatus, designated generally by the numeral 300, for applying both inductive and radiant heat to the mandrels and to the wound cords 50—50, respectively.

The cords 50-50 coiled on the associated mandrels 160-160 are destined to be heated beyond the transition temperature of the plastic jacketing material thereby softening the plastic material and causing the plastic material to adjust to the coiled configuration. Subsequently, when the coiled cords 50—50 are cooled, the coiled configuration becomes permanent. The time required to carry out these steps is a function of the differences between the ultimate temperature of the heated cord and the transition temperature. The larger that difference, the shorter the cooling time. However, care must be taken in that excessively high temperatures could permanently damage the cords.

Of course, the temperatures to which the outwardly facing surfaces of the cords **50**—**50** and the mandrels **160**—**160** are heated are a function of the composition of the jacket **51**, the insulation of the conductors **54**—**54**, and the thickness of these materials.

The temperature difference across the cord **50** affects the quality of the finished retractile cord. In order to obtain optimum retractility of a coiled configuration, the entire cross section, and not just the outer surface of the cord **50**, must reach the transition temperature during heating. Prior art heating of wound cordage appears to have been limited to heating of the outer surface of the convolutions or preheating the mandrels but not the combination thereof.

The preheating of the mandrels **160**—**160** and the infrared heating of the cord **50** cooperate to yield several desired advantages. The time required for heating effectively the cordage to impart a coiled configuration thereto is reduced. Further, the temperature differential across the cordage is reduced thereupon achieving a more uniformly heated cord.

In the first step position of one of the workholders **102**—**102**, the mandrels **160**—**160** are heated inductively by coils **301**—**301**, which are mounted adjacent the mandrels. The mounting of the coils **301**—**301** and the configuration thereof is accomplished to balance the heat input into each of the mandrels **160**—**160**.

The coils **301**—**301** are comprised of a copper tube having cooling water flowing therethrough. The coils **301**—**301** are operated at 6000 volts and 350 RF amps of an alternating current source to establish a magnetic field which elevates the temperature of each of the mandrels **160**—**160**. This is surprisingly effective in reducing the amount of lag of the temperature at the cord-mandrel interface behind that at the outwardly facing surfaces of the convolutions of the cords **50**—**50** and avoids overheating the outer surface of the cords in order to accomplish the cord heating within a short time span suitable for conveyor adaptation.

A radio frequency induction heating system operating in a range of frequency of 300-450 **KHz is available commercially from Lipel Company of Long Island, New York. The range of frequency is selected to be suitable to heat only the material of the mandrels** 160—160 **and not the plastic material of the cords** 50—50.

An apparatus, designated generally by the numerals **310**, is operated to apply infrared heat to the coiled cordage **60** on each one of a group of mandrels. The apparatus extends over five steps in the conveyor **101**. The apparatus **310** includes a housing **311**, which encloses five banks **312**—**312** of heating elements **313**—**313**.

The infrared heating elements **313**—**313** are available commercially for example from Research, Inc. of Minneapolis, Minnesota under the designation Pyropanel. Each of the infrared lamps of this apparatus is a tungsten-filament argon atmosphere lamp, which operates at approximately 1000° F at rated voltage. The apparatus **310** includes approximately ten to twelve lamps per bank, which covers approximately one foot along the conveyor **101**. The infrared heating elements **313**—**313** are effective to elevate the temperature of the outwardly facing portion of the wound cords **50**—**50**.

It should be understood that when one group of the mandrels **160**—**160** is in step **6** in the heating apparatus **300**, being exposed to one of the banks **312**—**312** of infrared heat elements **313**—**313**, successive groups of the mandrels are in steps two through five also being exposed to the infrared heat source. Moreover, another group is in the first step of advancement through the heating station **105** whereat the mandrels **160**—**160** thereof are being preheated inductively.

Further, as each workholder **102** is advanced by the conveyor **101** through the heating zone **106**, provisions are made for causing each mandrel **160** to be turned so as to increase the uniformity of the heating.

The preheating of the mandrels together with the subsequent exposure of the cords **50**—**50** to infrared heat throughout the next successive five steps results in a more uniform temperature across the cordage **60**. Although the prior art includes the exposure of the cordage to radiant or infrared heat or to the induction heating of the mandrels **106**—**160**, it does not appear to be known to preheat inductively the mandrels followed by infrared exposure of the coiled cords. The mandrel **160** is preferably a solid rod but may be hollow.

The cooperation of the inductive preheat and of the radiant heating are effective to obtain rapid heating of the cords **50**—**50** to that temperature effective to heat set and thereby impart permanent retractility to the cords. This is accomplished in a time span which equates to a short distance along the conveyor **101** while avoiding undesirably excessive heating of the outwardly facing portions of the cords **50**—**50**.

When exposed to a constant heat flux input at the outer surface, the cords **50**—**50** experience an initial heating transient after which the temperature increases at a constant rate and the temperature difference across the cord becomes constant. Although high radiant heat flux would facilitate high production, it unlike the cooperative inductive and radiant heating apparatus **300** undesirably increases the temperature variation across the cord **50**.

Cord Cooling

Following the heating of the cord **50** coiled on each mandrel **160** in a group, the group is advanced on the conveyor **101** for a relative short distance, for example, one to two feet, through the ambient atmosphere and then through a cooling station **108** whereat the cord is exposed to high velocity chilled air. The cooling station **108** includes apparatus, designated generally by the numeral **330** and which is operated to move chilled air at a velocity in excess of **400** feet per minute across the surfaces of the convolutions of the cordage. This causes the temperature of the cord jacket **56** to be decreased.

It will be appreciated that the space-winding initially of the cordage **60** increases the efficiency of the infrared heating and air cooling of the cordage since not only are the outwardly facing surfaces of the flat cordage exposed but also side portions thereof. This is significant in providing the capability of heating and cooling the cordage within a short distance thereupon avoiding the need of a lengthy conveyor. Further, as noted hereinbefore, the spacing apart of the convolutions of each of the wound cords **50**—**50** avoids advantageously any possible adhesion of adjacent ones of the convolutions.

Mandrel Orientation

As mentioned hereinbefore, it is important to the cord removing that the mandrels 160—160, which are moved into the cord remove-reverse station 109 be oriented such that the trailing end portions of the cordage on each one thereof held by the portions 177—177 of the double clamp assemblies 170—170 are oriented downwardly. This is accomplished by a device, designated generally by the numeral 350 (see FIG. 12), as the mandrels are moved along by the conveyor 101 beyond the cooling zone 107.

In order to permit the device 350 to orient, if necessary, any mandrel 160, each workholder 102 is provided with an assist member 351 which is connected to and extends laterally of each workholder. As each workholder 102 is moved to the left as viewed in FIG. 12 by the conveyor 101, it is moved past a sloping face plate 352 attached to the frame 103. If the assist member 351 is depending downwardly, it is engaged by the sloping face plate 352, which is effective to turn the assist member 351 slightly in a counterclockwise direction, as viewed in FIG. 12, and as shown on the workholder 102 to the extreme right position in that view. This is effective to turn slightly the sprockets 133—133 and hence the mandrels 160—160.

Subsequently, in the next step of the advance of the conveyor 101, the workholder 102 comprising four mandrels 160—160 is moved into alignment with a U-shaped member 353, which is mounted slidably in a guideway formed between two overhang plates 354 and 356 and two base plates 357 and 358. The U-shaped member 353 is moved upwardly perpendicularly by an air cylinder 359, which is connected to U-shaped member through a piston rod 361.

The upward movement of the U-shaped member 353 to receive the mandrel between the legs of the U causes the assist member 351 to be engaged by the legs and moved to an upstanding position as shown in FIG. 12. Of course, the assist member 351 is not turned pivotally if it is already in the upstanding position. If the orienting device 350 included only the U-shaped member, the mandrels could possibly be misoriented. For example, if the assist member 351 were oriented downwardly prior to being aligned with the U-shaped member 353, it would remain so when the U-shaped member was moved about the workholder and mandrels 160—160 would be 180° out of the desired position. As will be recalled, the desired position is one selected such that the trailing end portion of the cord 50 is oriented downwardly to facilitate removal and reversal of the cord from the mandrel.

The next successive incremental advance of the conveyor 101 causes the assist member 351 to be advanced past a device 362, which is attached to the frame 103. Since the assist member 351 will have been priorly oriented upwardly, the device 362 turns the sprocket 133 clockwise as viewed in FIG. 12 to complete the orienting of the workholders 102—102 and hence of the leading and trailing ends of the coiled cords 50—50.

Remove-Reverse

Following the orientation of the mandrels 160—160 which insures that the trailing end portion of each wound cord in each group of mandrels is directed downwardly, the workholder 102 is advanced incrementally into the cord remove-reverse station 109 (see FIG. 1). At that station, each wound cordage, now heat set and cooled, is removed from its associated mandrel while the pitch of the helices thereof is reversed to improve the retractile properties of the finished cord 50.

The unwinding of each coiled 50 begins with the end thereof which was severed from the associated supply 60 at the cord-coiling station. It should be apparent that the clamp assembly 171 must be disengaged from engagement with the associated cordage. An apparatus, designated generally by the numeral 400, is particularly adapted to accomplish this function.

Referring now to FIGS. 14 and 15, it is seen that the apparatus 400 includes a pair of parallel support rods 401 and 402, disposed perpendicularly of the path of travel of the cords, which are mounted in blocks 403 and 404, respectively, supported from the general framework 103. A plate 406 extends between the rods 401 and 402 and has two brackets 407 and 408 cantilevered out therefrom. The brackets 407 and 408 support spaced bearings 409—409 through which extends a vertically disposed shaft 411.

The shaft 411 is adapted to be turned rotatably in the bearings 409—409. In order to accomplish this, a clevis 412 is attached to the shaft 411 and is pin connected to an extension 413 of a piston rod 414 of an air cylinder 416. The air cylinder 416 is mounted pivotally to a bracket 417 attached to a member 418 extending from the plate 406.

The shaft 411 has a plurality of pawls 421—421 extending laterally thereof, each of the pawls being associated with and disposed adjacent an associated one of the mandrels 160—160. The operation of the air cylinder 416 extends the piston rod 414 to turn the clevis 412 clockwise, as viewed in FIG. 13, which turns the shaft 411 and moves pivotally the pawls 421—421 in a clockwise direction. This causes the pawls 421—421 to engage a portion of the flange end of the flanged hub 176 to urge the portion 177 upwardly as viewed in FIG. 15. The sliding movement of the portion 177 moves it out of confining engagement of the last wound convolutions of the cordage 60. It will be recalled that each group of mandrels 160—160 comprising a workholder 102 are oriented by the turning thereof counterclockwise through a 90° angle (see FIG. 12) prior to being advanced into the remove-reverse station such that the trailing and leading ends of the cord are extending downwardly.

The trailing end portion of each cord 50, which is oriented downwardly, is grasped and then urged in a path outwardly of the apparatus 100 to unwind the cordage. In order to accomplish this, the apparatus 100 is provided with a remover-reverser, designated generally by the numeral 430. The remover-reverser, as can best be seen in FIG. 13, includes a plurality of pairs of jaws 431—431.

FIG. 13 shows a pair of the jaws 431—431 and associated structure in various positions of the operation thereof. Each of the jaws 431—431 is attached to a pair of cam followers 432—432, which are received in a cam slot 433 and with one of the followers attached to a slidably mounted block 434. The slidably mounted block is moved by the operation of an associated air cylinder 436, which causes the one follower to be moved linearly within the associated slot while the other one of each set of the followers is moved along the arcuate portion of the associated slot to cause the jaw 431 to be moved pivotally to an open position, as shown in the FIG. 13(B) position.

It will also be seen in FIG. 13(B) that the block **434** is connected to a tension spring **437**. This permits a spring return of the block **434** after the jaws **431—431** have been moved to a position with the trailing end portion of the cordage disposed between the open jaws. The spring return of the block **434** causes the movement of the followers **432—432** along the linear portion of the cam slots **433—433** thereupon causing the jaws **431—431** to be moved to a closed position and in clamping engagement with the trailing end portion of the cord therebetween.

Further, as can be seen in FIG. **13**(B), the jaw assembly extends through a bellmouth guide tube **438** and is connected through an associated bearing assembly **439** to a drive gear **441** driven by a motor **442**. Once the jaws **431—431** have closed upon the cordage **60**, a limit switch **443** (see FIG. **13**(B)) detects the cam closing and spring return of the block **434**. This causes the operation of the motor **442** and concomitant turning of the jaws **431—431** and, simultaneously, the linear movement of the remover-reverser **430** away from the mandrels **160—160** for a predetermined distance.

The unwinding of the wound cord **50** from each of the associated mandrels **160—160** is accomplished desirably with a minimal amount of pull. Excessive pulling forces imparted to the cord will cause the cord to assume a stretched-out condition, which required undesirably additional amounts of expensive manufacturing floor space. Further, the imparting of excessive pulling forces to the coiled cordage as it is unwound causes desirably an enlarging of the helices and loss in retractility.

In order to overcome these potential problems and yet provide for the removal and the reversal of the cordage **60**, the apparatus **430** includes a plurality of stripper bars **446**, which are best seen in FIG. **16**. One of the bars **446-446** is associated with and disposed in alignment with each one of the mandrels **160—160**, which are advanced incrementally into the unwind position. The stripper bars **446—446** are mounted individually on associated arms **447—447** and **448—448** (see also FIG. **17**) extending laterally from a post **449**, which is moveable reciprocally by a piston rod **451** that is operated by an air cylinder **452**. Once each group of mandrels **160—160** have been indexed into the unwind position, the air cylinder **452** is controlled to move the arms **447—447** and attached stripper bars **446—446** to position the stripper bars such that an arcuate surface **453** of the stripper bar is essentially contiguous the outwardly facing surfaces of the convolutions of the associated coiled cordage **60**.

Then, when the jaws **431—431** are closed upon the trailing portions of the cordage, and the apparatus **430** moved out from the mandrels, successive sections of the cordage are in effect peeled off the mandrel **160** (see FIG. **16** (A)). This has been found to facilitate removal and reversal of the pitch of the helices with nominal tension while holding any enlargement of the convolutions desirably to a low amount, if any, over that as it existed on the mandrels.

The remove-reverse apparatus **430** also has provisions for moving the jaws **431—431** in a direction away from the associated mandrels **160—160** simultaneously with the rotation of the jaws and the rotation of the mandrels. The movements cooperate to reverse the pitch of the helices in each length of the cordage **60** and to produce a cord **50** having superior retractile properties. Some prior art facilities accomplish this by unwinding the convolutions from the original coiling mandrel and rewinding the convolutions with a reverse pitch onto another mandrel. This requires additional mechanisms and requires provisions for being able to remove the finally wound cordage **60** from its associated mandrel **160**. See U.S. Pats. Nos. 2,575,747 and 3,226,767, for example.

Referring now to FIG. **17**, it is seen that the rotatably mounted jaws **431—431** are mounted on a carriage, designated generally by the numeral **460**. The carriage **460** is mounted to be moved with a rack **464** in a direction angularly laterally of the mandrels **160—160**. As the carriage **460** is moved with the rack **464**, each wound cordage **60** is removed from the associated mandrel and moved through adjacent ones of the arms **447—447**. A predetermined amount of overtwist may be imparted to each of the cords. See, for example, U.S. Pat. No. 3,656,516, incorporated by reference hereinto.

When the trailing portions are removed from the mandrels **160—160**, the cord **50** has a tendency to knot and kink up individually and tangle with adjacent cords. Provisions must be made to secure the trailing end portions as the trailing end portions are unwound from the mandrels.

As the carriage **460** approaches an outer end limit of its travel, the carriage is moved adjacent a confining device **461** in the form of a plate **462** mounted vertically and having a plurality of slots **463—463** formed therein. Further movement of the carriage **460** angularly laterally of the mandrels causes portions of the cordage being unwound from the mandrels to be moved into and through associated aligned ones of the slots **463—463**. Each of the slots **463—463** has a flared entrance to facilitate the movement of portions of a cord **50** into the slot. The width of the slot **463** is slightly greater than the diameter of the cord when the cordage is in an extended taut condition and is less than the diameter of the convolution of the cord in a retracted condition but is greater than the diameter of the cordage **14**.

The principles of the confining device **461** are disclosed in U.S. Pat. No. 3,656,516 issued Apr. 18, 1972 in the name of E. C. Hardesty and incorporated by reference hereinto. However, in the apparatus of the present invention, the arrival of the carriage **460** at the end of the path of travel along the rack **464**, is accompanied by the operation of the air cylinders **436—436** to cause the jaws **431—431** to be opened to release the trailing ends of the wound cords **50—50**. The retention of the leading ends of the cords **50—50** within the associated ones of the slots **463—463** in the plate **462** holds the cords and prevents entanglement until an operator removes the cords. Advantageously, this is the only role played by an operator in the manufacture of the retractile cords other than to monitor the control of the operation.

Referring now to FIG. **18**, there is shown a device **470** in the cord-removal and reversing station **109** for causing the toggle clamp assemblies **154—154** to release the leading ends of the cords **50—50** wound on the mandrels **160—160**. A plurality of spaced members **471—471** having stepped ends **472—472** are attached to and extend from a support plate **473**. The support plate **473** has a pair of rods **474** and **476** mounted in end brackets **477** and **478**, respectively. The rods **474** and **476** extend through sleeve bearings **479** and **481**, respectively, which are held in a plate **482** that is connected to support rods **483** and **484**. The plate **482** is connected to one end of a piston rod **486** extending from an air cylinder **487** that is fastened to the plate **473**.

As can best be seen by viewing FIGS. **3** and **18**, the operation of the air cylinder **487** with the piston connected to the stationary plate **482** causes the plate **473** to be moved to the right as viewed in FIG. **18** to move the adjacent stepped ends of the members **471—471** into engagement with the studs **163—163** extending from the crank cams **161—161** of each of the mandrels **160—160**. This causes the crank arms **161—161** to be turned in a counterclockwise direction, as viewed in FIG. **3**, to move the ends **169—169** out of engagement with the leading ends of the cords **50—50**.

Operation

Initially, an operator inserts a leading end of each supply **61** of the cordage **60** into one of the cord-feeding devices **201—201** of which in a preferred embodiment there are four and depresses START palmbutton **499** to initiate the operation of an electrical control circuit, designated generally by the numeral **500** (see FIG. **19**). After the initiation of the operation of the apparatus **100**, it continues until a stop button (not shown) is depressed or malfunction occurs.

Prior to the initiation of the operation of the apparatus **100**, all of the elements of a pneumatic control system, designated generally by the numeral **600** (see FIG. **20**) must be in predetermined positions. If any of the elements are not in a BEGIN position, the operator is made knowledgable thereof through appropriate signals and the positions assumed prior to the beginning of the automatic continuous operation of the apparatus **100**.

It should be recognized that the apparatus **100** includes a plurality of work stations whereat a sequence of operations occur sequentially continuously as groups of mandrels **160—160** are loaded and then stepped incrementally through the apparatus on the endless conveyor **101**. In each station where multiple worksteps occur, each successive step occurs only if the preceding step had taken place. The sequence of operation is controlled by the electrical circuit **500**, which includes a turning mechanism, designated generally by the numeral **501**, which is provided with a motor **502**. The motor **502** operates a camming system (not shown) whereby a plurality of contacts of the timing mechanism are cam-controlled, thereby energizing a plurality of solenoids to control the operation of the apparatus **100**. It should be understood that this control system is exemplary only and others may be used in order to control the operation of the apparatus in accordance with the principles of this invention.

The following operational description is illustrative of the operation of the various controlling air cylinders and motors for the apparatus. Referring to FIGS. **19** and **20**, all air cylinders are assumed to be in an unoperated REST position. Thereafter the rotational movement of the motor **502** results in the cam closing of a contact **503** (see FIG. **19**) of the timing mechanism.

The contact **503** may be time or cam actuated to control the movement of the conveyor **101** and the workholders **102—102** through the workstations. Initially, it may be assumed that the closing and opening of the contact **503** causes the operation of the motor **127** to advance successive ones of the workholders **102—102** into the cord-coiling station **104** where the workholders dwell for a time sufficient to have a predetermined number of convolutions coiled thereon and severed from the supplies **61—61**.

This is followed by the closing of a contact **506** and energization of an associated solenoid **507**, which causes pneumatic pressure to be applied through a valve **607** to operate the air cylinders **229—229** (see FIGS. **3** and **6**) to move the pawls **225—225** and the anvils **226—226** of the feed nozzles **222—222** into juxtaposition with the toggle clamp assemblies **154—154**. Leading ends of the cordage supplies **61—61** are advanced into engagement with the associated mandrels **160—160** and extend transversely thereof (see FIG. **5**).

Then a contact **508** is closed to energize an associated solenoid **509** to cause pneumatic pressure to be applied through a valve **609** to operate the air cylinder **241**. This causes the rack **236** to be moved adjacent the toggle clamp assemblies **154—154** (see FIG. **9**). The linear movement of the rack **236** causes the operation of a limit switch **511**, which causes air to be supplied through a valve **612** to operate the air cylinder **238**. The operation of the air cylinder **238** is controlled to move the rack **236** linearly as shown in FIG. **8** to rotate the pinions **234—234** and associated cranks **231—231**. The cranks **231—231** are moved pivotally to engage the portions **165—165** of the arms **161—161** of the toggle clamp assembly **154—154** (see FIG. **4**(A)). This causes the arms **161—161** to be turned on the associated shafts **162—162** clockwise as shown in FIG. **4** to the position of FIG. **4**(B) to move the ends **169—169** to clamp the leading end portions of the cordages **60—60** in engagement with the mandrels **160—160**.

While the cam associated with the contact **503** is still in a dwell position, the turning of the motor **502** causes the switche **508** to be opened to return the cylinder **241** to an unoperated condition and thereby move the rack **236** laterally of the mandrels **160—160**. The movement laterally of the rack **236** disengages the rods from the limit switch **511** causing the cylinder **238** to return the crank arms **231—231** to an unoperated position.

The turning of the motor **502** causes the contact **506** to be opened thereupon deenergizing the solenoid **507** and causing the valve **607** to control the air cylinders **229—229** to withdraw the feed nozzles **222—222** from adjacent the mandrels **160—160**. The snubber **233** cooperates with the block **224** to prevent retrograde movement of the cordage **60** toward the supplies **61—61** thereof in the event that the leading ends have not been secured to associated ones of the mandrels.

Then a switch **513** is cammed closed to energize the operation of the cable cylinder **211** (see FIG. **3**) to cause the carriage **202** to be moved with the follower **216** along the cam slot **217**. Simultaneously, a switch **516** is closed to cause the operation of the motor **138** (see FIG. **1**) to cause the mandrels **160—160** to be turned rotatably. The turning of the mandrels **160—160** cooperate with the movement of the carriage **202** longitudinally laterally of the mandrels to cause a plurality of spaced-apart convolutions of the cordages **60—60** to be wound on the associated mandrels **160—160**.

After a predetermined movement of the carriage **202** along the path defined by the cam slot **217**, the carriage engages a limit switch **518** (see FIG. **3**), which causes a discontinuation of the operation of the cable cylinder **211** to move the carriage to the right as viewed in FIG. **3**. Then a switch **521** is closed to cause the operation of the ROTAC motor **259** to turn the shaft **254** and thereupon engage the fingers **251—251** with the associated ones of clamp assemblies **171—171** (see FIGS. **9** and **10**). This causes a sliding movement to be imparted to the portions **177—177** to move those portions over the last one or ones of the convolutions of the cordages **60—60** on each of the mandrels **160—160**.

Subsequently, a switch **523** is closed to energize an associated solenoid **524** to cause pneumatic pressure to be applied through valves **624—624** to air cylinders **277—277**. This causes an operation of the severing apparatus **270** to move the plates **272—272** and blocks **281—281** to sever the cordage **60** extending from each mandrel **160** into the associated feed nozzle **222** in two spaced locations to avoid the hereinbefore described problem of "suck-back". The severance of the cordage **60** from that wound on the mandrel **160** permits the retractile properties of the cord **50** to whip the trailing end portion about the mandrel through a 180° angle to the position shown in FIG. **9** where advantageously it remains with the convolutions held by the portions **177—177** against further unwinding.

The switch **523** is opened to deenergize the solenoid **254** and cause the air cylinders **277—277** and associated severing apparatus to be returned to then unoperated positions. Moreover, a switch **526** is closed to initiate the operation of the cable cylinder **211** in a reverse direction to return the carriage **202** to the left as shown in FIG. **3** in preparation for coiling cordage **60** on the mandrels of the next successive workholder **102** indexed into the cord-coiling position.

The switch **503** is closed to operate the motor **127** to move the just-loaded workholder **102** in a counterclockwise direction, as viewed in FIG. **1**, to a first step of the plurality of steps in the cord-heating station **107**. At that time, of course, although this description is made with reference to one workholder **102** the loading of which has just been described, it will be understood that successive ones of the workholders are advanced into the workstation **104** and loaded with cordage **60**.

In the first step of the cord heating station **107**, a switch **520** is closed to cause the coils **301—301** which are positioned over the mandrels **160—160** and operated to heat inductively the mandrels. Of course, this causes the initiation of the heating of the wound cordage **60** on each of the mandrels. After a predetermined time which, of course, coincides with the conclusion of the loading of the mandrels **160—160** now in the cord-loading position, the switch **503** is reclosed to again operate the motor **127** and index the workholder **102** under consideration into the first of a plurality of stations in the cord-heating zone **107** where the mandrels are exposed to the infrared head device **310** within the housing **311**. This causes a heating of the exterior outwardly facing surfaces of the convolutions of the cord **50**. The infrared heating supplemented by the induction heating of the mandrels causes a bidirectional heating of the cordage to thereby more effectively heat the cordage within a short distance of travel.

Through subsequent openings and closings of the switch **503**, the conveyor **101** is indexed to advance incrementally the workholder **102** through each of the work stations in the chamber **311** to complete the infrared heating of the cords to set the configuration thereof on the mandrels **160—160**.

Further, openings and closings of the switch **503** causes the workholder to be advanced incrementally a short distance through the ambient atmosphere and then into and through the cooling chamber **330** where facilities cause chilled air at a relatively high velocity to be moved into engagement with the cord **50** to cool the cordage to permit further processing thereof.

A subsequent advance of the conveyor **101** moves each of the mandrels **160—160** of the workholder past the orienting device **300** (see FIG. **12**) such that the plate **352** insures that each assist **351** is angled to a vertical axis and as shown in FIG. **12**. Then a switch **528** is closed to engage a solenoid **529** and cause air to be supplied through a valve **629** to the air cylinder **359** to move the U-shaped member upwardly to turn the mandrel, if necessary, to the required oriented position to prepare mandrels of that workholder **102** for a final turn by the device **362** to orient the cordage **60** to have the trailing end thereof grasped. Moreover, a cylinder **359'** at the return leg of the conveyor **101** is operated to reorient the workholder **102** prior to advance thereof into the cord loading position for a subsequent cycle of cord winding.

Further, cam-timed openings and closings of the switch **503** cause the workholder **101** to be advanced incrementally into the cord remove-reverse position **109**. A switch **530** is closed to cause the carriage **460** to be moved toward the workholder **102** in the removal position until a limit switch **531** (see FIG. **13**) is operated. This discontinues the movement of the carriage with each of the sets of jaws **431—431** justaposed about the associated trailing end of cordage (see FIG. **13(C)**).

At that time the trailing and leading ends of the cordage **50—50** are oriented downwardly. A switch **536** is closed to energize a solenoid **537** to cause pneumatic pressure to be supplied through a valve **637** to the air cylinder **436** to withdraw the jaws **431—431** into the guides **438—438** to close the jaws on the trailing end portions of the cords **50—50**. After the trailing end portions have been grasped, a switch **538** is closed to energize a solenoid **539** to supply pneumatic pressure through a valve **639** to the cylinder **416**. This moves the pawls **421—421** pivotally to move slidably the portions **177—177** of the clamp assemblies **171—171** to uncover the last-wound convolution of each cord **50**.

Then a switch **541** is cam-closed to energize a solenoid **542** to cause a valve **642** to control the cylinders **452—452** to move the stripper bars **446—446** in proximate engagement with the wound cords **50—50** (see FIG. **16**).

Then a switch **546** is cammed closed to a motor **465** to move the carriage **460** along the rack **464** (see FIG. **17**) from the conveyor **101** to unwind the cords **50—50** with the successive sections of the cordage being moved under the stripper bar **446**. As the motor **465** turns the pinion **466**, the carriage **460** is moved longitudinally orthogonally of the mandrels **160—160** while the jaws **431—431** are being turned rotatably. The stripper bars **446—446** facilitate unwinding with minimum pulling forces and thereby avoid undesired enlargement of the convolutions.

As each cord **50** is unwound from the associated mandrel **160**, successive sections are moved axially and generally perpendicularly of the plate **462**. Then as the carriage approaches the end of its travel, portions of the cordage adjacent the trailing end portions are moved into the flared entrance portions **464—464** of the slots **463—463**.

Then a switch **551** is closed to energize a solenoid **552** to cause a valve **647** to control air cylinder **487** to cause the members **471—471** (see FIG. **18**) to engage the other end portions **165—165** of the toggle clamp assemblies **154—154** to release the leading end portions of the cords **50—50**.

The continued motion of the carriage **460** causes the last few convolutions bo be unwound from each mandrel **160** and portions of the cordage moved through the associated slot **463** toward the inner closed end thereof.

The friction engagement of segments of each cord **50** with the bottom wall of the slots **463—463** exerts a drag therein and permits the last few convolutions to expand to the original diameter thereof. The trailing end portions of the cordage **60** engages the walls of the slots **463—463** to hold the cordage.

At the end of the predetermined path of travel of the carriage **460**, the switch **546** is opened, which causes a discontinuation of the operation of the motor **465** and hence the movement of the carriage. The switch **536** is opened to cause the air cylinder **436** to be operated to open the jaws **431—431** to release the ends of the cords **50—50** after which an operator removes the cords from the plate **462**.

Then the switch **530** is closed to cause the motor **465** to turn in a reverse direction to return the carriage **460** to a position adjacent the cord-unloading or removal-reverse position for another cycle of operation with the next successive group of mandrels **160—160**. As the carriage **460** is returned along the rack **464**, the jaws **430—430** are caused to be turned rotatably and a slot pin **467** is operated to an extended position until it engages a stop **468** whereupon the jaws are oriented for the next cycle.

Subsequently, the conveyor is indexed and on its return to the cord-coiling position **104**, the workholder **102** just unloaded is moved through a second orienting device **370** identical to the device **350** but on the lower return leg of the conveyor (see FIG. **1**). This is operated to orient the clamp assemblies **150** and **170** to be positioned properly to clamp leading and trailing end portions of cordage **60** once the workholder is reindexed into the cord-coiling position **106**.

It is to be understood that the above-described arrangements are simply illustrative of the invention. Other arrangements may be devised by those skilled in the art, which will embody the principles of the invention and fall within the spirit and scope thereof.

What is claimed is:

1. A method of making retractile cords each having a jacketed plurality of individual conductors, which includes the steps of:

providing a plurality of elongated workholders in spaced-apart parallel relationship to one another along a continuous path of travel substantially normal of the longitudinal axes of the workholders;

advancing a leading end of a supply of cordage into engagement with one of the workholders in registration with a cord-loading work station;

securing the leading end of the supply of cordage in engagement with each successive workholder in the cord-loading work station;

winding a plurality of convolutions of the cordage on successive ones of the workholders in registration with the cord-loading work station to form a helically wound cord on each successive workholder such that adjacent ones of the convolutions are spaced apart and the wound cord has inwardly and outwardly facing portions with respect to its associated workholder;

clamping the last wound convolution in engagement with the workholder;

severing the wound cord from the supply of cordage to form a trailing end portion extending from the workholder and a leading end portion from the supply such that the trailing and leading end portions each includes jacketed conductors;

indexing each successive loaded workholder along the path of travel while simultaneously moving successive empty ones of the workholders into the cord-loading work station;

heating each successive loaded workholder to facilitate heat transfer from the workholder generally conductively into the inwardly facing portions of the convolutions, and causing radiant heat transfer into the outwardly facing portions of the convolutions of the cords on successive ones of the workholders while simultaneously winding cordage on the next successive ones of the workholders in the cord-loading work station;

cooling the cord wound on each successive one of the loaded workholders to facilitate removal subsequently of the cord from the workholder;

interposing a guide surface adjacent the wound portions of the cord on each successive one of the workholders in a cord removal work station;

twistingly rotating the ends of the helically wound cord on each successive one of the workholders in the cord removal work station relative to each other to reverse the direction of the pitch of the helices thereof; while

causing relative movement between the trailing end and the wound portion of each successive one of the wound cords to unwind the cord form the workholder with successive sections of the cord being moved past the guide surface to minimize enlargement of the convolutions; and

engaging unwound portions of the cord adjacent to the other end of the cord prior to the cord being unwound completely to secure the other end of the cord when the cord is unwound completely.

2. The method of claim **1**, wherein the severing of the wound cord from the supply is accomplished by severing the cordage at two spaced locations intermediate the wound cord and the supply of cordage whereby the newly formed leading end portion of the cordage includes end faces of the individual conductors generally flush with the end face of the jacket.

3. The method of claim **1**, wherein each of the cords is wound on a mandrel, and the heating of the mandrels is accomplished electrically inductively, the heating of the cords is accomplished subsequently by radiant heat transfer, and the cooling of the cords is accomplished by convective heat transfer.

4. The method of claim **1**, wherein each workholder includes a plurality of mandrels and the cordage is wound in spaced-apart convolutions simultaneously on each of the plurality of mandrels of each successive one of the workholders in the cord-loading position by moving the cordage extending to the supply laterally of the workholder while turning rotatably the workholder.

5. A method of making retractile cords from a supply of cordage, comprising the steps of

advancing a plurality of elongated rotatable workholders in spaced parallel relationship along a continuous path normal to the elongated workholders through a cord-loading station, a heating station, a cooling station and a cord removal-reversal station;

winding helically a plurality of spaced-apart convolutions of cordage from a supply on each empty workholder in response to the positioning thereof at the cord-loading station, the wound cordage having inwardly and outwardly facing portions with respect to the associated workholder, further, the cordage wound on each workholder having leading and trailing unwound end portions which extend from the workholder in the same direction;

severing the cordage wound on each of the workholders from the supply while the workholder is in the cord-loading position;

heating each successive loaded workholder to facilitate heat transfer from the workholder generally conductively into the inwardly facing portions of the convolutions, and causing radiant heat transfer into the outwardly facing portions of the convolutions of the cords on each successive loaded workholder while simultaneously winding cordage on at least one empty workholder in the cord-loading station;

cooling the cordage wound on the loaded workholders as the workholders are moved through the cooling station;

turning each workholder about its longitudinal axis, if necessary, in order to orient the leading and trailing unwound end portions of each cord in a predetermined direction to facilitate removal of the wound cord from the workholder;

removing the wound cordage from each associated workholder at the removal-reversal station in a manner to reverse the pitch of the helices of the convolutions of the wound cordage while minimizing enlargement of the helices thereof; and

preventing entanglement of the convolutions of the cordage wound on each workholder prior to complete removal thereof from the associated workholder at the cord removal-reversal station.

6. The method which includes the steps of claim **5** and further which includes prior to the step of winding the convolutions of cordage on an empty workholder in the cord-loading station the step of advancing and securing the leading end of the supply of cordage to the empty workholder in the cord-loading station.

7. The method of claim **5** wherein the heat transfer into the outwardly facing surfaces of the convolutions of each is accomplished subsequent to the heating of each of the workholders.

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UNITED STATES PATENT AND TRADEMARK OFFICE

Certificate

Patent No. 4,075,299 Patented February 21, 1978

Gordon Foreman Bloxham, Claude Paren Brezeale, Eugene Raymond Cocco, Edwin Charles Hardesty, Byron Lee Small, Daniel Marion Steinert and Charles McGonical

Application having been made by Gordon Foreman Bloxham, Claude Paren Brezeale, Eugene Raymond Cocco, Edwin Charles Hardesty, Byron Lee Small, Daniel Marion Steinert and Charles McGonical, the inventors named in the patent above identified, and Western Electric Company, Incorporated, New York, New York, a corp. of New York, the assignee, for the issuance of a certificate under the provisions of Title 35, Section 256, of the United States Code, adding the name of Michael Alfred Cole as a joint inventor, and a showing and proof of facts satisfying the requirements of the said section having been submitted, it is this 17th day of March 1981, certified that the name of the said Michael Alfred Cole is hereby added to the said patent as a joint inventor with the said Gordon Foreman Bloxham, Claude Paren Brezeale, Eugene Raymond Cocco, Edwin Charles Hardesty, Byron Lee Small, Daniel Marion Steinert and Charles McGonical.

FRED W. SHERLING,
Associate Solicitor.